LIVERPOOL

GEOLOGICAL ASSOCIATION.

TRANSACTIONS.

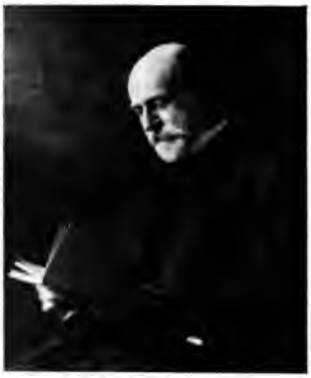
VOLUME VII.

SESSION 1886-7.

LIVERPOOL:
PRINTED FOR THE ASSOCIATION BY J. DONALD, 556, PRESCOT ROAD,
OLD SWAN.

1887.

THREE SHILLINGS.



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INDEX.

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The Authors are alone responsible for the facts and opinions expressed in their Papers.

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ERRATA.

Page 53, line 25 from top, for "Percy Street," read "Hope Street."

Page 75, line 22 from top, for "east," read "north-west."

LIVERPOOL

GEOLOGICAL ASSOCIATION.

ANNUAL REPORT,

1886.

LIVERPOOL GEOLOGICAL ASSOCIATION,

FREE LIBRARY, WILLIAM BROWN STREET, LIVERPOOL.

———:o:———

Council:

PRESIDENT:

A. NORMAN TATE, F.I.C.

VICE-PRESIDENT:

H. T. MANNINGTON.

MEMBERS OF COUNCIL.

I. E. GEORGE,	P. H. MARROW,
W. H. MILES,	C. E. MILES,

J. R. WEBB.

TREASURER:

T. R. CONNELL,

Melville Chambers, Lord Street, Liverpool.

SECRETARY:

D. CLAGUE,

81, Lime Grove, Liverpool.

The above form the Executive.

Librarian: E. EVANS.

Superintendent of Excursions: I. E. GEORGE.

Registrar: C. F. WEBB.

Publishing Committee: A. N. TATE, D. CLAGUE, I. E. GEORGE AND W. H. MILES.

Liverpool Geological Association.

:o:

ANNUAL REPORT,

SESSION 1885-6.

4th OCTOBER, 1886.

At the close of another year your Council have to report that 8 new members have joined the Association. On the other hand, our numbers have been reduced in various ways by 26 names, leaving the number now on the books at 136. Amongst our losses we regret to have to record the removal by death of the following gentlemen, viz.:—Messrs. F. J. Lawrenson, R. G. New, and Capt. Shilston.

During the year we have held 11 Ordinary Meetings, at which the following papers were read:—

"The Trias Sandstone," by P. H. Marrow.

"The Geology of South East England," by C. Potter.

"Fossil Reptiles," by T. Brennan.

"Micro-Photography, an Aid to Geological Study," by E. Dickson.

"Report of a Microscopic Examination of Certain Limestones," by H. C. Beasley.

"Alpine Pictures and Geological Notes from Switzerland," by T. S. Hunt.

"Work done in the Boulder Clay," by H. F. Hall, F.G.S.

"Carbonic Acid, and its Work in Nature," by H. Robson, B.Sc.

"The Bronze Age." Communicated.

"Strontia, its Minerals and their Uses," by H. Fox.

"Gibraltar," by W. H. Quilliam, B.A.

Besides these papers many interesting communications were made; and objects of interest, gathered during the rambles of our members, have been exhibited at the meetings, adding much to their success.

During the winter months a series of meetings were held in the Museum, on Saturday afternoons, when the following subjects were studied from the objects in the cases:—

"The Cephalopoda," explained by Rev. H. H. Higgins, M.A.

"Bones of the Hand," A. W. Audon.

"Corals, and Kindred Animals," P. H. Marrow.

"Sponges," D. Clague.

"The Echinodermata," W. Narramore.

"The Limulus, and Allied Forms," Prof. Herdman, D.Sc.

These meetings were well attended and proved to be very instructive; arrangements will be made to resume them during the ensuing winter.

During the summer months Field Meetings were held as follows:—

April 26.	Broxton.	*Conducted by*	C. E. Miles.
June 21.	Carnforth.	,,	C. Ricketts, M.D., F.G.S.
Aug. 2.	Llangollen.	,,	J. Brown & I. E. George.
,, 28.	Dawpool.	,,	C. E. Miles.

Sept. 11. Lea Green Colliery. A joint excursion with the Science Students' Association.

These proved to be very successful, and our thanks are due to Mr. George for the efficient manner in which he has arranged and carried out these series of Museum Visits and Field Meetings.

The Library, under the care of Mr. E. Evans, is in good condition, and it is much appreciated by the members, as is shown by the increasing number of readers. It has been enriched by donations of books from Dr. Ricketts, F.G.S., and

Messrs. T. Mellard Reade, F.G.S., and T. R. Connell, to whom also our thanks are due.

TRANSACTIONS AND REPORTS have been received from the following Societies, to each of which copies of our Transactions have been sent in exchange:—

Barrow-in-Furness Free Library.

Belfast Naturalists' Field Club.

Burnley Literary and Scientific Society.

Chester Society of Natural Science.

Edinburgh Geological Society.

Geologists' Association (London).

Leeds Geological Association.

Liverpool Engineering Society.

,, Entomological Society.

,, Free Public Library.

,, Geological Society.

,, Naturalists' Field Club.

,, Polytechnic Society.

,, Science Students' Association.

Manchester Geological Association.

,, Students' Association.

Mining Association and Institute of Cornwall.

Smithsonian Institution, Washington, U.S.A.

Yorkshire Philosophical Society.

The Transactions are in the Press, and the Editor, Mr. W. H. Miles, promises to have them in the hands of the members shortly.

During the year several of our members have removed from Liverpool to distant parts of the country, and we have had pleasing proof that they have not lost interest in our work, for several of them have contributed papers to be read at our meetings. It is to be hoped that all our members residing at a distance will keep up an active connection with us, and com-

municate to the Association matters of interest from their several localities.

Members residing in the neighbourhood are urged to use efforts to make our meetings still more effective. Much work may be done in holiday seasons, and it would be well if, on their return home from holiday trips, they would communicate to our meeting reports of their observations and work.

There are problems suggested by the rocks on which we live which await solution; and work in that direction might, with advantage, be undertaken by our members.

The financial report appended shows a balance in hand of £5 19s. 2d.

At this meeting the Officers and Council for the year will have to be elected in accordance with Rule III.

LIVERPOOL GEOLOGICAL ASSOCIATION *in Account with the Treasurer,*

FOR THE YEAR ENDING SEPTEMBER, 1886.

Disbursements.

		£	s.	d.
1886.				
September.	To Printing and Stationery	19	16	6
	,, Postages and Incidentals	8	18	3
	,, Cash in Treasurer's hands	5	19	2
		£34	13	11

Receipts.

		£ s. d.	£ s. d.	£ s. d.
1885. Sept.	By Balance brought forward			11 16 5
1886. Sept.	,, Subscriptions, viz.:—			
	136 Members at 5/-		34 0 0	
	11 Members paid in advance in previous years	£2 15 0		
	62 Members in arrears	15 10 0		
	— 73 —		18 5 0	
	63 Subscriptions for year 1885-6		15 15 0	
	1 Subscription for 1882-3		0 5 0	
	3 ,, 1883-4		0 15 0	
	5 ,, 1884-5		1 5 0	
	5 ,, 1886-7		1 5 0	
	— 77			19 5 0
	,, Receipts from Members for Printing ...			3 12 6
				£34 13 11
	By Balance brought down			£5 19 2

LIBRARY FUND.

	£ s. d.	£ s. d.
By Balance brought down	£0 6 6	
,, Donation	0 5 0	
		0 11 6

Audited and found correct,

(Signed) JOHN MORRIS, J. KIRKHAM DALE, } AUDITORS.

THOS. R. CONNELL, TREASURER.

Liverpool, 30th September, 1886.

LAWS

OF THE

Liverpool Geological Association,

ESTABLISHED 3rd JUNE, 1880.

RULES PASSED 15th NOVEMBER, 1880.

OBJECT.

The object of the LIVERPOOL GEOLOGICAL ASSOCIATION is to promote the study of Geology and its allied Sciences.

RULES.

I.

That every Candidate for Membership shall be proposed and seconded by two members of the Association, and balloted for at the next Ordinary Meeting; and the consent of three-fourths of the members then present shall be necessary for the admission of such Candidate.

The proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

II.

Every member shall pay an annual subscription of Five Shillings, payable on the 1st October, or, in the case of a new member, within one month after election. Any member not paying the subscription within three calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

III.

The Officers of the Association shall be a President, Vice-President, Treasurer, Secretary, and five other members, who together shall constitute the Council to manage and direct the affairs of the Association. Five to form a quorum. The officers shall be elected at the Annual Meeting to be held in October; retiring officers shall be eligible for re-election. Any vacancy occurring during the year shall be filled up by the Council.

IV.

The Treasurer's Financial Statement shall be presented to the Association, with the Annual Report, after having been duly audited by two members proposed, seconded and elected at the last meeting of the Session.

V.

The Ordinary Meetings shall be held on the first Monday in each month, at eight o'clock in the evening. The order of proceeding at such meeting shall be:—

1.—The ordinary business of the Association.

2.—Miscellaneous Communications.

3.—Original Papers or Communications, to be followed by discussion thereon.

4.—Announcement of business for the next Meeting.

VI.

A Special Meeting may be called at any time by the Council; and they shall be bound to call such a meeting on receipt of a requisition signed by not less than ten members, stating the purpose for which the meeting is to be convened. Seven days' notice of a Special Meeting shall be given to every member, such notice to specify the business to be considered; and the meeting shall be held within twenty-one days after the receipt of the requisition. No other business shall be considered at a Special Meeting, except that for which it has been called.

VII.

Field Meetings shall be held at places of geological interest, but none of the private business of the Association shall be transacted on such occasions.

VIII.

The votes on any question brought before the Association shall be taken by a show of hands, except those for the election of officers and new members, which shall be taken by ballot.

IX.

The manuscript of every Paper read, or a clear and legible copy thereof, written on foolscap, shall become the property of the Association, and shall be placed in the Library for the use of the members.

X.

In case of non-compliance with the Rules of the Association, or misconduct by any member, such member may be requested by the Council to resign. Failing to do so, the Council may bring the case before a meeting of the Association, which shall deal with it as may seem expedient.

XI.

Every member may introduce a friend at any Ordinary or Field Meeting of the Association, provided, however, that no person qualified to become a member be admitted as a Visitor more than twice in the same year.

XII.

No addition to, or change in these Rules shall be made except by a majority of not less than two-thirds of the members present at a Special Meeting to be convened for that purpose.

LIVERPOOL GEOLOGICAL ASSOCIATION.

FORM A.

M...

....

being desirous of admission to the Association, We, the undersigned, recommend h   as a proper person to become a Member.

Dated..................18

Proposed by..

Seconded by..

Date Proposed..

Date Elected.......................... ....

Signature of Candidate....................................

..............................Secretary.

REGULATIONS FOR THE ADMISSION OF MEMBERS.

RULE 1.—That every Candidate for membership shall he proposed and seconded by two members of the Association, and balloted for at the next ordinary meeting; and the consent of three-fourths of the members then present shall be necessary for the admission of such Candidate.

The Proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

RULE 2.—Every Member shall pay an annual Subscription of Five Shillings, payable on the 1st October. or, in the case of a new member, within one month after election. Any member not paying the subscription within three calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

LIVERPOOL GEOLOGICAL ASSOCIATION.

:o:

LIST OF MEMBERS,

Session 1885-6.

Ashton, F. W.	4, Richmond Terrace, Breck Road.
Auden, Anthony W.	20, Cable Street.
Banister, H. C.	Rossett Road, Crosby.
Barber, J. M.	4, Eyes Street, Breckfield Road North.
Beasley, H. C.	Leam Cottage, Wavertree.
Beecham, G. C.	16, South Hunter Street.
Bellamy, C. R.	Cecil Villa, Grosvenor Road, Liscard.
Brennan, Thomas	30, Granton Road.
Biram, Benj., Assoc. M. Inst. C.E.	St. Helens, Lancashire.
Biram, B. Swinton, B.A.	Sherdley, St. Helens.
Bramall, H., M. Inst. C.E.	Pendlebury Colliery, Manchester.
Broadfoot, Bruce M.	67, Huskisson Street.
Brodie, Alexander	202, Upper Parliament Street.
Brown, Jos.	37, Exe Street.
Browne, A. H.	31, James Street.
Cade, Lawrence W.	15, Upper Parliament Street.
Capon, R. M., L.D.S.	114, Vine Street.
Carter, C. W.	
Clague, Daniel (Secretary)	81, Lime Grove, Lodge Lane.
Clarke, F. C.	87 Alwyn Street.
Conlon, Bernard	22, Mount Pleasant.
Connell, T. R. (Treasurer)	Melville Chambers, Lord Street.
Cooper, W. R., B.A.	11, Northumberland Terrace, Everton.
Cotter, Mrs. B.	10, Oxford Road, Waterloo.
Currie, Luke	3, Lord Street.

Dale, J. K.	124, Islington.
Davies, David	Lochburn Iron Works, Maryhill, Glasgow.
Defieux, C.	98, Herschell Street.
Deuchar, P. B.	17, Kingsley Road.
Dickson, Edmund	30, Eastbourne Road West, Birkdale.
Duff, Samuel	55, St. Martin's Cottage, Ashfield Street.
Dunsford, A. J.	Wynch House, Seacombe, Cheshire.
Edwards, F. W.	Fairhope, Victoria Park, Walton.
Evans, E. (Librarian)	35, Beresford Road, Toxteth Park.
Evans, J. C.	37, Ranelagh Street.
Elias, O. H.	Mere House, Mere Lane, Everton.
Frazer, John	1, Railway Cottages, Spekeland Road.
Findlow, John	42, Percy Street.
Finlay, R. F.	Slater Court, Castle Street.
Fowler, Thomas Richard	139, Crown Street.
Fox, Herbert	
Gasking, Rev. Samuel, B.A.	West View, Cowley Hill, St. Helens.
Gray, John A.	86, Alfred Street.
Gray, G. Watson	12, Argyle Road, Garston.
George, Isaac E. (Member of Council) (Superintendent of Excursions).	89, Beaconsfield Street.
Gregson, G. E.	11, Chapel Street, Preston.
Grisewood, W.	Liscard Park, Liscard, Cheshire.
Hall, Henry, H.M. Inspector of Mines	Rainhill.
Hall, Hugh F., F.G.S.	Greenheys, Grove Road, Wallasey, Cheshire.
Hancox, John	101, Prescot Street.
Hedley, J.L., H.M. Inspector of Mines	The Gables, Flooker's Brook, Chester.
Henson, Samuel	277, Strand, London, W.C.
Hewitt, William, B.Sc.	21, Verulam Street.
Hills, William	
Holbrook, The Hon. Henry	Parkgate, near Chester.
Houlding, John	34, Tynemouth Street.
Hunt, T. S.	140, Allerton Road, Woolton.
Johnson, T. M.	116, Duke Street.
Johnston, W. H.	6, Latham Street, Preston.
Jones, R. T.	32, Canning Street.
Jones, W. A.	32, Laurel Road, Edge Lane.
Jones, W. Joinson	7, Rhiwlas Street.

Keyte, T. S., C.E.	68, Adswood Lane, E., Stockport.
Kirkmann, H.	Oswell Bank, Seaview Road, Liscard, Cheshire.
Kissack, J. M.	18, Newland Street, Everton.
Labouchere, J. M.	106, Spencer Street.
Lewis, A. E.	74, Rogerson's Quay, Dublin.
Lister, R. F.	8, Ashfield, Wavertree.
Littlewood, T.	Sheffield.
Maguire, T.	108, Landseer Road.
Mannington, C. E.	61, Rawcliff Road, Walton.
Mannington, H. T. (Vice-President)	61, Rawcliff Road, Walton.
Marrat, Frederick P.	21, Kinglake Street.
Marrow, Fred.	
Marrow, P. H. (Member of Council)	31, Bell Road, Seacombe.
Martin, William	14, Normanby Street.
Miles, Charles E. (Member of Council)	57, Willow Bank Road, Higher Tranmere, Cheshire.
Miles, W. H. (Member of Council)	41, Whetstone Lane, Birkenhead.
Mitchell, C. T., F.S.Sc.	College School, Huyton.
Moore, Miss Emily	1, Sheen Road, Sea Bank Road, Liscard.
Moore, T. J., C.M.Z.S.	The Museum, William Brown Street.
Morgan, C. H.	72, Bank Road, Bootle.
Morgan, James	City Engineer's Office, Dale Street.
Morris, John	4, The Elms.
Morris, Mrs. John	4, The Elms.
Narramore, W.	5, Geneva Road, Elm Park.
Nicholls, John	11, Chatham Place.
Owen, William	4, Comus Street.
Owens, Philip	45, Clarendon Road, Egremont.
Padley, F.	15, Church Street.
Pain, C. Squarey	14, North John Street.
Paton, Rev. William	The Ferns, Parkside, Nottingham.
Potter, Charles	101, Miles Street.
Plastow, James	169, Great Homer Street.
Pritchard, D. D.	22, Tancred Road, Anfield.

Quilliam, W. H., B.A.	49, Rufford Road.
Ranford, Miss S.	25, St. George's Road, West Derby Road.
Reade, T. Mellard, C.E., F.G.S., F.R.I.B.A.	Park Corner. Blundellsands, Lancashire.
Ricketts, Charles, M.D., F.G.S.	22, Argyle Street, Birkenhead.
Roberts, Isaac, F.G.S.	Kennessee, Maghull.
Roberts, J. Meredydd	91, Cawdor Street.
Roberts, Robert	9, Northumberland Terrace.
Robins, G. J.	Ashton Cross, Newton-le-Willows.
Robson, Herbert, B.Sc.	Wesley College, Sheffield.
Robson, George	66, Roscoe Street.
Robson, Mrs	17, Nile Street.
Rowett, Charles	126, Granby Street.
Rowlands, T. V.	89, Duke Street.
Rundell, T. W.	Litherland Park.
Schweitzer, W.	2, Ashfield, Wavertree.
Small, Laurence	71, Geraint Street.
Shilston, Mrs. H. P.	1, Saltoun Terrace, Seacombe.
Shilston, Thomas, M.I.N.A.	31, Westmoreland Road, Newcastle-on-Tyne.
Simpson, L. C.	Falkland Road, Egremont, Cheshire.
Smith, Edward	15, Upper Parliament Street.
Storey, John	21, Falkner Square.
Tapscott, R. L.	41, Parkfield Road.
Tate, A. Norman, F.I.C. (President)	9, Hackins Hey.
Tate, George, Ph. D., F.G.S.	College of Chemistry, 96, Duke Street.
Tate, John A.	
Tildesley, H. F.	78, Woodville Terrace, Everton.
Thomas, Hopkin	4, Cable Street.
Thorp, Josiah	8, Gladstone Road.
Walker, William H.	40, Castle Street.
Ward, Thomas	Northwich, Cheshire.
Webb, Cecil F. (Registrar)	46, Wellington Terrace, West Derby Road.
Webb, John R. (Member of Council)	29, Fountain Street, Higher Tranmere.
Westcott, H.	94, Prince's Road.
Wigzell, Miss M.	22, Russian Drive, Tue Brook.
Wilding, James	92, Troughton Street.

Williams, J. J.............................. 3, Ducie Street.
Williams, Miss L .... 55, Rocky Lane, Newsham Park.
Williams, T. H.............................. 2, Chapel Walks.
Wright, W.................................... 86, Hulton Street, Moss Side, Manchester.

Young, Henry .... 12, South Castle Street.

The following are proposed and stand for election at the next meeting:—

Ballard, Rev. F., M.A., F.G.S.... .... Kirkdale.
Davies, S.......................... .... 115, Heyworth Street.

ABSTRACT OF PROCEEDINGS

OF THE

Liverpool Geological Association,

SESSION 1886-7.

ANNUAL MEETING,

Held at the Free Library, October 4, Mr. H. Bramall, M. Inst. C.E., President, in the chair.

Member Elected.—Mr. G. C. Beecham.

Candidates Nominated.—Rev. F. Ballard, M.A., F.G.S.; Mr. S. Davies.

The Annual Report and Treasurer's Statement of Accounts were read and adopted, and the following Officers for the Session 1886-7 were elected according to Rule III.—

President.—A. Norman Tate, F.I.C., F.C.S.

Vice-President.—H. T. Mannington.

Secretary.—D. Clague.

Treasurer.—T. R. Connell.

Council.—I. E. George, C. E. Miles, W. H. Miles, P. H. Marrow, and J. R. Webb.

During the evening a number of Photographs of Scenery illustrating the geological features of the country, and mineral and rock specimens, representing the work done by members during the year, were exhibited, including

Photographs of	Port St. Mary,	exhibited by	Mr. J. Kissack.
,,	Rocky Mountains	,,	Mr. Read.
,,	Vale of Cheddar	,,	Miss L. Williams.

Rock Specimen from Carnforth, exhibited by Mr. George.
Italian Marbles ,, ,, ,, Mr. J. K. Dale.

Minerals and Rock Specimens from the Carboniferous Shale of Ormeshead, by Mr. P. H. Marrow.

German and Canadian Kieselguhr, by Mr. Mannington.

Rock Specimens from the Oolites of Scarborough, and from the Eocene beds of the London Basin, by Mr. D. Clague.

Album of Photographs, exhibited by Mr. O. W. Jeffs.

VISIT TO MAGHULL FOR THE STUDY OF LUNAR VOLCANOES,

On Friday, October 8th, when the members accepted the invitation of Mr. Isaac Roberts, F.G.S. In the course of an introductory address, Mr. Roberts explained the features of the moon's surface by reference to those on certain parts of the earth. Spreading before them maps and photographs of the extinct volcanoes of Central France, he compared them with photographs of the moon; then, when the eye was familiarised with the features to be examined, he placed his 7-inch refracting telescope at the use of the members, who were thus enabled through his assistance to study for themselves the landscapes of the moon, special attention being directed to the Craters Tycho and Archimedes, and the ridges of the lunar Appenines with the adjoining Crater Copernicus.

ORDINARY MEETING,

Held at the Free Library, Monday, Nov. 8, 1886, Mr. A. N. Tate, F.I.C., President, in the chair.

MEMBERS ELECTED.—Rev. F. Ballard and Mr. S. Davies.

The Secretary announced the appointment by the Council of the following officers :—

Librarian.—E. EVANS.

Superintendent of Excursions.—I. E. GEORGE.

Registrar.—C. F. WEBB.

Publishing Committee.—A. N. TATE, D. CLAGUE, I. E. GEORGE, and W. H. MILES.

DONATIONS.—"Geology," by Prof. Prestwich, *presented by*

Mr. A. N. Tate, F.I.C.; "Lepidoptorous Fauna of Lancashire and Cheshire," by Dr. Ellis, *presented by the Author;* and the following reports, &c., by the respective Societies and Institutions:—Journal of Liverpool Astronomical Society, vol. 4; Ditto, ditto, part 1, vol. 5; Annual Report and Proceedings of Liverpool Science Students' Association, 1885-6; Fourth Annual Report of Free Public Library, Barrow-in-Furness; Proceedings of Liverpool Geological Society, 1885-6.

The President, Mr. A. Norman Tate, F.I.C., then read an address, of which the following is an abstract.

ON SOME POINTS OF GEOLOGICAL TECHNOLOGY, OR THE PRACTICAL APPLICATIONS OF GEOLOGICAL STUDY.

In speaking to you this evening on some points of Geological Technology, I might find a fruitful topic in the discussion of the effect of geological teaching in the past in widening men's minds by opening up new and important lines of thought and study; or I might speak of the great aid geology has rendered to coal and metalliferous mining, and the searching for and obtaining precious stones; or of its help in gaining good and plentiful water supplies; or of the assistance it has given to the engineer in his road making, canal cutting, tunnelling, excavating, and draining; or of its value to the architect, builder, agriculturist, and manufacturer.

On all these topics the geologist may ponder with feelings of pride and pleasure, in knowing that the science he loves has been productive of such great results.

But whilst looking back to the past with feelings of satisfaction, I would rather now look forward and endeavour to point out how, in my opinion, geological science may be made even more serviceable.

One mode of doing this is to give more detailed study to the

objects that come under notice. Take, for example, the weathering of rocks. This is a grand subject in relation to alterations that have taken place or are taking place on the earth's surface, but if worked out in greater detail than is usual, may afford information of much value in some of the business of daily life.

For example, many of our public and private buildings are much disfigured, and some even rendered dangerous by decay of the stone they are built of, and this is chiefly because the weathering effects on the stone were not sufficiently understood before it was built into the edifice. Now, if a geologist finding new exposures would make it a systematic practice, not only to study stratigraphical position and general structure and appearances, but also carefully note chemical characters, minute mineralogical structure, porosity, texture, fracture, and other physical characters, and report fully on all these, he would not only add much to his own knowledge and pleasure of investigation, but oftentimes give information that could be made available in many ways in practical every day work. Only those geologists who have given minute attention to this subject of weathering can have any idea of its importance in reference to the permanence or decay of buildings, or the wear and tear of paving stones, &c., the selection of clays for brick making, furnace work, puddling, &c., &c.

The examination of the special characteristics of different limestones could also prove of great value, not only in considering geological problems concerning their formation, alteration, &c., but in teaching very much that is useful in selecting lime for agricultural and chemical purposes, the manufacture of cements, or for the making of mortar, or other building purposes.

The detailed examination of rock constituents ought also to aid in selecting better sites for wells than have often been chosen, by avoiding positions where rock constituents can

add materially to the substances contained in the water, or bring about variations in the water supplied.*

Much may be done also in making geology available in technical directions, in giving more minute study to the result of geological action in other parts of the globe. The emanations from volcanic eruptions, the residues from dried up lakes, and similar matters, are well worth closer attention than yet given them, and commerce and manufactures may be increased by studying them to a fuller extent.

Time will not allow me this evening to give more examples, but probably what I have already said will serve to illustrate the sort of study I wish to see carried on, in order to make geological investigations even more useful than they have been.

But this more detailed attention to geological matters requires that the geologist shall assist himself with a fuller knowledge of mineralogy, chemistry, and microscopy; not that these only are the sciences a geologist should bring to his aid, for the study of the whole of the structure and history of our earth requires for the geologist an almost universal knowledge, but these can prove of the greatest use to him.

Especially valuable in noting rock composition is micro-chemistry, and I strongly urge upon geological students the desirability of giving more attention to the examinations that can be carried on by its use.

And remembering the very great assistance given by geology to certain branches of technology in the past, I would strongly advocate the systematic teaching of this science to those whose occupations have relation to it, such as those engaged in coal and metalliferous mines, architects and builders, sur-

* The several decompositions rock material can undergo through the influence of exposure to the atmosphere, water, mechanical conditions, &c., were spoken of, and the modes of testing the physical and chemical characters of stone for building, paving, and other purposes, were described in detail, as also the variation in clay deposits, and modes of treating all these by simple experiments to ascertain their properties for certain technical purposes. Tests suitable for examining different strata in regard to suitability for water supply were also mentioned.

veyors, engineers, well sinkers, &c. The technical instruction of persons such as these cannot be considered complete without a fair knowledge of geology.

Another great aid to technical geology might be found in the systematic collection and arrangement of records of all new exposures, excavations, tunnellings, &c., &c., by geological Societies, each Society giving careful attention to its own district. The records might not only be written, but sketches should be added, and frequently the use of photography, as suggested by Mr. O. Jeffs, would be valuable.

In conclusion, let me say that my desire is that our studies during the session shall be made practically useful. We know that Geology has done good service in the past, and so let each one of us strive his very best to increase its value and renown in the future.

ORDINARY MEETING,

Held at the Free Library, Monday, December 6, 1886, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the chair.

DONATIONS.—Proceedings of the Geological Association (London), Nos. 6 and 7, vol. ix; Journal of the Liverpool Astronomical Society, part 2, vol. v; *presented by the Societies*; "Notes on the occurrence of Copper in the Keuper Sandstone," by O. W. Jeffs, *presented by the Author*; a set of Geological Maps of the South Australian Gold Fields, *presented by the School of Mines, Australia, per Mr. Allan S. Caine*.

EXHIBITS.—The Secretary exhibited a curious trumpet-shaped mass of sandstone, which had formed the core of a mass of contorted rock in a quarry near West Derby. Mr. C. F. Webb also exhibited a number of fossils.

A paper was read

ON THE GEOLOGY OF ROUEN,

BY THE REV. S. GASKING, B.A. F.G.S., &c.

(ABSTRACT.)

In the course of an interesting account of a voyage to Rouen, the Author gave many geological and physiographical details noticeable on the coast, on the passage up the Seine, and in the country near Rouen. At Havre, close to the pier, the chalk rises gently till it forms the bold promontory of Cap la Héve. The first rising ground is about 30 feet high, and is covered rather deeply with reddish clay, sand, and broken flints. A little further on, at the foot of an eminence about five or ten feet higher, there may be readily distinguished in the sand several species of shells still to be found existing in the immediate district in small numbers, but especially plentiful on the opposite side of the estuary. These show that the land hereabouts has gained a height of a few feet in a pretty well limited time. Passy believes the sand containing these recent shells to be a part of the ancient

mouth of the Seine. The principal cliff is composed of the Lower or Grey Chalk. There is, however, a peculiarity about it, which interferes with our attempted English classification of the chalk. There are in the Upper Chalk in our own country flinty bands. Strange enough, the cliff in this locality contains a quantity of flints, and a great number of beds of chert nodules of a good size, at the transition into the Upper Greensand. The Cretaceous, Wealden, and Kimmeridge formations are to be studied under the lighthouse at Cap la Héve, and are exposed also in the cliff beyond the lighthouse. They have received notice at the hands of Passy, Audouin, and Le Seur among French, and of Mackie and Austin among English geologists. Proceeding with difficulty up the steep front of Cap la Héve, an interesting deposit of silicious sand is reached. This contains several kinds of shells of recent date, and is overlaid by common flint-gravel, rather angular in shape, and not worn at all. In the direction of the port a bluish marl is to be seen dividing the sandy beds into two portions, but this marl soon gently vanishes, so that at no great reach the bed becomes a green sand of a somewhat clayey character. Advancing some way inland, this district is found to be capped in an irregular manner by a deposit of clay-gravel enclosing angular flints.

Proceeding towards Rouen, on the right side of the estuary, close to Trouville, the Upper Greensand is to be observed. It attains an elevation of about 330 feet according to Hébert, covering, in the first instance, the Jurassic rocks, and then the reddish sands of the Lower Cretaceous rocks. This formation has been subjected to some considerable disturbance, for it appears at a fault at Lillebonne, and owing to this same powerful upheaving influence a fault is to be noticed at Villequier, on the left side of the river as we go up, where the sands are raised to a height of 264 feet above the level of the sea. This exceedingly great upheaval presents the shape of a grand amphitheatre round this village. The beds, Hébert certifies, are on a N.W. and S.E. anticlinal, dipping away about

45° to S.W., and 30° to N.E. Proceeding further up the river through the contracted channel which runs through numerous sandbanks, and noting on the way the embankments and dredging operations that have largely improved the navigation, and the large tracts of land reclaimed and placed under cultivation, we reach Candebec and Quilleboeuf, where the estuary ends, and where also the tributary Rille pours its waters into the Seine. At Tancarville on the left is the entrance to the canal for Havre. At length La Bouillé is reached. It is at the base of a steep hill on our right. There are, in a quarry not very far away, some excavations, which are celebrated for their stalactites, as well as for the numerous passages which penetrate a considerable distance underground.

At Duclair, on the left side, the chalk has been burrowed into by some poor people, who thus provide for themselves habitations. Here the river meanders considerably till at last Rouen is reached, and although but 45 miles east of Havre in a direct line, the many windings of the river make the distance nearly double. On the east side of the city, immediately above the bank of the Seine, between that river and its tributary the Aubette, is St. Catherine's Hill, 380 feet high, one of the boldest and most singularly abrupt of the eminences which form the peculiarly pleasing features of this neighbourhood. As seen on approaching it from the city, it presents a steep side of pure chalk, curiously spotted with verdure, and dotted by cottages stuck here and there. The views from the top are exceedingly good. The magnificent Seine winding in and out through enchanting scenery, having in its midst little islands clothed with vegetation or pleasantly wooded. The hill abounds in marine fossils. From a quarry on the left large masses of the rock are constantly being removed, and a great number of specimens can be readily obtained. This abrupt eminence exhibits the union of the Upper White Chalk with the Chalk Marl, and the lower Chloritic Chalk or Greensand. Although there may be no room for suspicion as regards the identity of the formation of these rocks, still there is to be

found, on investigation, a very considerable palæontological difference. In the last named are numerous fossils which are unlike, in a considerable degree, those organic remains obtainable from the Upper White Chalk. Here, then, is a section particularly suitable for geological purposes, as this union is of great value in determining the formation to which the strata may be referred, notwithstanding the fact of the strange divergence from each other in the matter of the fossilized organic remains imbedded in their midst. The Chalk Marl and the Greensand may be observed at Cap la Héve, but not the White Chalk. This inferior chalk agrees in every respect with that so finely developed in the South East of England, extending as it does from Folkestone to Dover on the coast. The White Chalk and Chalk Marl are separated from the Greensand by a bed of clay-marl of a bluish colour.

The following is a list of the fossils of commonest occurrence at this spot:—Nautilus simplex, Scaphites obliquus, Ammonites varians, A. Rotomagensis, A. Coupei, A. Gentoni, Hamites rotundus, Turrilites costatus, Cassis avellana, Podopsis truncata, Inoceramus concentricus, Pecten dubius, Plagiostoma spinosa, Trigonia striata, Terebratula semi-globosa.

The indurated chalk of the neighbourhood has been largely used for building purposes in Rouen, and enters into the composition more or less of many erections, both old and new. The splendid Church of St. Ouen, which rivals the Cathedral in size and form, is almost all constructed of chalk of a particularly hard character, in which are to be seen the flints, which have been industriously carved through by the patient individuals whose business it was to shape the massive blocks. As a matter of weathering of building stone, it may be mentioned that, although fairly durable, this stone shows considerable evidence of disintegration.

MUSEUM VISIT.

On Saturday, December 18, the members met at the Museum to study the Iron ores in the Phillips' collection of minerals, under the guidance of Mr. H. T. Mannington, who briefly described the physical characters of the principal Iron ores, Magnetite, Hæmatite, Limonite, Chalybite and Pyrites.

He also described the occurrence of the great deposits of Iron ore: Hæmatite in the Carboniferous Limestone; and Limonite, Magnetite and the various forms of the Carbonate found in the Clay ironstone, the Black band in the Coal Measures, and the Cleveland ores of the Middle Lias.

The processes by which the Iron oxide disseminated through the strata in an insoluble form becomes soluble through the agency of organic matter, and thus, by means of circulating water, is dissolved and deposited in suitable places as beds of ore, were explained in detail. Some particulars were also given of the amount of ore raised in the United Kingdom, from which it appeared that about one-half comes from the Coal measures and the Carboniferous limestone; the remainder being derived almost entirely from the Lias and Oolite formations.

ORDINARY MEETING,

Held at the Free Library, Monday, January 3, 1887, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the chair.

Nomination.—Mr. G. H. Webb, M.D., D.D.S., Ph. D., of 46, Wellington Terrace.

Donation.—Journal of Liverpool Astronomical Society, part 3, vol. v., *presented by the Society*.

Exhibits.—Mr. C. F. Webb exhibited a case of American Minerals. The Maps recently presented to the Association by the Department of Mines, Victoria, per Mr. Allan S. Caine, were also on view during the evening.

Associated Soiree.—The Secretary reported that the Association had taken part in the Annual Soiree of the Associated

Literary, Science and Art Societies, which was held in St. George's Hall on December 15th, and had contributed an exhibit on that occasion, which included the following items:—

Mineral Ores of Commercial Importance.—Mr. A. N. Tate.

Iron and Manganese Ores.—Mr. G. W. Gray.

Cornish Minerals.—Messrs. I. E. George, H. T. Mannington and T. Hunt.

Cumberland Minerals.—Messrs. T. R. Connell and Joseph Brown.

Italian Marbles.—Mr. J. K. Dale.

Devonian Fossil Fishes and Lower Lias Cephalopoda. — Mr. S. Henson.

Instruments for taking the Specific Gravity of Rocks and Minerals.—Mr. D. Clague.

And a Series of Geological and Physiographical Photographs, by Messrs. A. N. Tate, T. H. Williams and Miss Williams.

A Paper was read

ON THE SAND-DUNES OF THE CHESHIRE COAST,

By C. Potter.

(abstract.)

The Author first briefly alluded to the several characteristics of the new red sandstone of the district, specially mentioning its numerous faults, varying colours, differences in density and permeability, and peculiarities of stratification, ranging from what is evidently due to deposition in or levelling by water to that known as contorted sandstone, with its numerous flexures and short irregular bends, and other irregularities of bedding; and then stated that, by noting what actually occurs amongst the Sand-dunes, and observing the many phenomena presented by blown sand, he had come to the conclusion that similar results had occurred during the formation of the triassic sandstone. He then went on to say—If the natural sections made in the sandhills during the storms

of winter and early spring are carefully studied, there may be found flexures, bends and contortions analagous in every way to those of the new red sandstone. These arise entirely from the direction and force with which the sand is brought into places sheltered from the storm which has set it in motion. The vegetation of the district, if covered by the blown sand, soon finds its way through the new deposit. The vegetable mould covering the hollows and many of the hills contributes from its exposed margins a sufficient quantity of material, when combined with the annual decay of the vegetation, to cause a distinct separation from the next deposit of sand that may be drifted upon it.

The carving of the sand-hills is the work of every storm, the material removed from one hill going to add to the growth of others, or to fill the narrow valleys and the nooks and corners, thereby giving many curves and bends, each deposit conforming itself to what it lies upon, and varying with the force of the wind and the direction from which it blows. Considerable differences of colour may be seen in these deposits.

Horizontal beds several feet in thickness, bearing evidence of having been deposited in or levelled by water, can be seen in the sand cliff immediately above the littoral at Great Meols, and also to the east of the Wallasey embankment, when the tides have swept from these parts the loose sand or talus.

In wet seasons water accumulates and stands for considerable periods amongst the hills; and on the margin of these pools, locally known as "flashes," may occasionally be found large numbers of footprints of such birds as sea-gulls, sandpipers, and others that frequent the littoral. In the spring and early summer there may also be found those British batrachians, the toad and frog, and these leave their footprints, as their colossal representatives of the Triassic period have done at Storeton and elsewhere. The footprints are left in the moist sand, or more frequently in the fine argillaceous deposit left as a covering where the water has stood for any considerable time. This deposit must be derived from the almost

impalpable material washed out of the sand-hills during heavy rains. With a clear sky and hot sun the water rapidly disappears, and the argillaceous deposit becomes almost like sunburnt pottery. In its semi-dried or plastic state, this deposit is very impressible, and capable of retaining the impressions made by birds, frogs, insects, rain-drops, &c., and these are protected by the blown sand that next covers the surface; whilst the newly deposited drift-sand forms the base for a further accumulation of matter from the waters that collect during the next wet season. Thus many deposits might be formed which, becoming indurated, would produce slabs dependent for thickness on the quantity of sand drifted on the surface of one aqueous deposit before the next was laid upon it. An examination of the conditions surrounding the markings at Storeton lead to the conclusion that they have been formed in a similar manner.

Amongst the sand-hills may also be found considerable surfaces of ripple markings caused by the wind, horizontal beds which would give current bedding, and, amongst the earliest deposits, thin beds of a ferruginous and argillaceous character of a very great extent. From whence is the ferruginous and argillaceous character of these deposits derived? The sand blown inland from the littoral, whether in Cheshire, Wales or Lancashire, is uniform in colour and character, whilst in the older deposits, as the contorted triassics, the colour of even the smallest beds is dependent on the quantity of oxide of iron enveloping each grain of sand. The sand on, and that freshly blown from, the littoral, except where there is leakage from the hills, being of one uniform lighter colour, the ferruginous colouring cannot come from thence.

It will be found in the old horizontal beds which vary from a few tenths of an inch to several inches in thickness, and the theory I would now advance is that it has been brought up from the Upper Scrobicularia, and the Boulder clays by the action of such plants as the Starr-grass and Dwarf-willow, the stems and roots of which penetrate through the whole

thickness of the hills and underlying strata to the boulder clay.

In my opinion, the roots of these plants have in the past proved misleading to many local geologists and members of the ordinance survey, they having taken them, where exposed by denudation, for the roots and rootlets of the forest trees imbedded in the peats; and they have, further, described these peat beds at one time as land surfaces or soils formed under terrestrial arboreal conditions, and again have called them, what I believe them to be, peats. In noting the character of the post-glacial beds of the district, the student would do well to give attention to the growth of the characteristic plants of the blown sand, as these are greatly instrumental in the building up and holding together of the drifting loose material of the newly formed hills.

The terminal of the starr-grass has a sharp, almost horny spur, adapted for penetrating through the beds to where a sufficient supply of moisture is to be obtained, and the best place to seek for the stem is in the face of a newly exposed section of a sandhill. The willows rise to the tops of the hills, but oftener are found in the lower ground, and the growth spread out in a circle, increasing as years roll on, and uniting with other families until spaces many acres in extent are covered. It is in the earlier stages of growth that these willows have proved misleading to local geologists, as when found standing out from the Scrobicularia clay or Boulder clay, petrified into the fossil state by oxide of iron, and extending in a circle of from three to thirty feet, they have given rise to the conclusion that they were the roots of trees imbedded in the peats above.

To account for the almost total absence of fossils in the triassic sandstone many theories have been advanced; amongst others, that the water holding in suspension the iron that has given hardness and colour to the stone, would contain to so great an extent carbonic acid that shells would be dissolved; but in the green sands of the Cretaceous period and the

Wealden are to be found beds so similar in appearance that in cabinet specimens they might be mistaken for Triassic; yet they abound in fossils. If the carbonic acid would destroy the calcareous remains of mollusca, would it also destroy the horny scales and siliceous teeth of fish, when these remains are covered by standing water beyond the reach of atmospheric influence? If not, then some other cause must be sought for.

French geologists assert that "burial under water is a necessity to the fossil state." May it not then be asked, has there been an absence of water during the Triassic period? The large accumulations of salt which are found in the Triassic formation may help to an answer. Whence can the salt have been obtained except by the process of evaporation from the waters of an ocean? And might it not be assumed that during the earlier stage of the evaporating process, the water attained a saltness too great to sustain organic life, and that, therefore, life in it would be an impossibility. Much of our salt being deep down in the Triassic formation, either the hollows containing it must have existed as deep pits or caverns, or the rocky matrix surrounding and overlying it must have been built up whilst the rock salt was being formed by the process of evaporation.

Again, in support of the theory that the non-saliferous rocks of the Trias are derived from accumulations of blown sand may be mentioned, in addition to the presence of footprints already alluded to, the occurrence of the fossil teeth of batrachia, a few of which have been found. The presence of these indicates the terrestrial character of the formation, as, although these creatures are amphibious, it is only fresh water that they frequent, and that principally during the spawning season.

Referring to the fact that amongst the sand-hills the girdled snail is found somewhat abundantly, and also the bones of rabbits, and large quantities of comminuted shells, and that, therefore, if the triassic sandstones are formed from

the sand-dunes, similar remains should be found in them, I would say that, exposed to the influences of the sun and atmosphere, combined with the effects of carbonic acid in rain water, these accumulated organic materials rapidly decay, liberating lime, &c, which being carried by the rain water down to the level at which the water stands, would tend to bind together and indurate the loose sands.

MUSEUM VISIT.

On Saturday, Jan. 15, the members visited the Museum for the purpose of studying the Life of the Lias Period. Mr. D. Clague pointed out the great contrast between the barrenness of the Trias period in both plants and animals, and the great abundance of life in the Lias period, and drew special attention to the abundance of Lamellibranchiata, the beauty and variety of the Cephalopoda, and the unique character of the Reptilia, his remarks being illustrated by the specimens in the cases.

ORDINARY MEETING,

Held at the Free Library, Monday, February 7, 1887, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the chair.

Mr. G. H. Webb, M.D. was ELECTED a member.

Mr. W. H. Gowsell was NOMINATED for membership.

DONATIONS.—Abstract of Proceedings of the Geological Society of London, Nos. 493 to 498, *presented by* Mr. G. H. Morton, F.G.S.; Journal of the Liverpool Astronomical Society, Feb. 1887; Report and Proceedings of Manchester Scientific Society, vol. for 1886; and Transactions of Manchester Geological Society, vol. xix., part 2, *presented by the Societies;* Memoirs of the Geological Survey of the district around "Prescot" and "Southport," and "Origin of Mountain Ranges," by Mr. T. Mellard Reade, *presented by* Mr. A. N. Tate.

The remainder of the evening was devoted to a study of the Physiographic Geology of a number of interesting places

in the British Isles, photographs of which were exhibited by Mr. Bernard Conlan with an excellent oxy-hydrogen lantern.

Views of North Wales were described by Mr. D. D. Pritchard, who pointed out the scenery characteristic of the Cambrian rocks in the neighbourhood of Barmouth, and noted the fact that in that formation there is now being worked a bed of Carbonate of Manganese which is about 18 inches thick, the first instance of that mineral being mined in the British Isles, the yield being 25 to 30 per cent. of Metallic Manganese. Silurian and Carboniferous Limestone scenery in the neighbourhood of Llangollen also passed under review. Evidences of glacial action were distinctly pointed out at Lake Ogwen and the Passes of Llanberis and Aberglasllyn.

Mr. I. E. George described the Geology of the Channel Islands, including Jersey, Guernsey, Alderney and Sark. Special attention was drawn to the structure of the Syenitic districts in those islands, and to the action of the sea in widening the joints until they were enlarged into fissures and channels, producing caves, natural arches, rock-bound bays and sunken rocks.

Mr. A. Norman Tate, F.I.C., described Irish scenery. Commencing at Bray Head he referred to the disintegration of the rocks of that neighbourhood, and traced the influence of mountain streams and rivers in wearing out ravines and glens, such as are seen near Powerscourt, in the Dargle, and in the Devil's Glen. He then spoke of the silting up of lakes and the formation of fertile valleys, described the scenery of the Vale of Ovoca, and mentioned the mineral deposits found in that locality, concluding with remarks on some features of the Lakes of Killarney.

MUSEUM VISIT.

On Saturday, February 19th, a meeting was held at the Museum, William Brown Street, at which an address was delivered by the Rev. H. H. Higgins, M.A. on Coal Fossils, collected by him at Ravenhead, from the upper portion of the middle coal measures.

Amongst the fossils described were Sigillaria, many specimens of which were exposed during the excavations at the time of making the railway, all the tree stumps being about five feet in height, indicating, probably, that the district had been flooded to that height, and that decay had set in more rapidly in the trees at that level, so that they readily snapped asunder there.

The Calamites and Ferns were also described. Special attention was also directed to the Sternbergia or Ringed Stones, which had been found in the Dadoxylon, as a pith in the centre of the stem, whilst Cordaites and Nœggerathia are probably the foliage of the tree, the fruit of which, however, has not been found.

After the address, Mr. Higgins conducted the company along the galleries, and pointed out, in the cases there, the fossils he had been describing.

ORDINARY MEETING,

Held at the Free Library, Monday, March 7, 1887, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the chair.

Member Elected.—Mr. W. H. Gowsell.

Donations.—Abstract of Proceedings of London Geological Society, and Pamphlets by W. Whittaker, F.G.S., *presented by Mr. G. H. Morton, F.G.S.;* a Pamphlet on Ravenhead Coal Fossils, by Rev. H. H. Higgins, M.A., *presented by the Author;* Set of Geological Maps of the District on six inch scale, *presented by the President*; Report of the British Association, 1885, *presented by Mr. J. C. Evans.*

EXHIBITS.—A Dolomitic slab, containing impressions of the Dragon Fly, exhibited by Mr. C. F. Webb; a series of rock specimens, both in the original and altered condition, showing the result of chemical action upon rock constituents, exhibited by Mr. P. H. Marrow; Microscopes, with sections of Pitchstone and Dolerite, shown by the President.

The President gave a brief resumé of recent contributions to Geological Science, which will be found under the head of "Notes of the Month." He said he particularly wished to call the attention of members to the very many interesting items connected with geological, physiographical and mineralogical research, appearing in the scientific journals and publications now issued, and he believed the suggestion that had been made, that a short abstract of these, together with other short notes, added to the ordinary monthly "Transactions," would prove of very great assistance to members.

A Paper was read on

WIND EROSION,

By ISAAC E. GEORGE.

The study of the action of wind-borne particles of rock upon each other, and upon the more stable masses over which they may be drifted, is a branch of Dynamical Geology, the study of which has, until quite recently, lain somewhat in the background; but the microscopical researches of Sorby, and the explorations carried on by the United States Geological Survey, have now brought the subject to the front, with the result that æolian action, as it has been called, is now regarded as one of the potent forces of denudation. The American geologists, working over immense areas where little or no rain fell, proclaimed that the work of earth-sculpture there carried on was largely of æolian character; whilst the labours of the English geologist, applied to a study of sand grains derived from the granitic coast-line of Cornwall, showed that the structure of these small bodies was very different from what we had always imagined. It need scarcely be said that sand

—mainly composed of quartz fragments—is the universal polisher in nature. Practically insoluble in the presence of the ordinary agents of chemical disintegration, quartz-sand survives where other materials would be reduced to powder, or carried away in solution; while its superior hardness gives it a great erosive power when moved about by the wind. Primarily, this material is derived from the disintegration of granite and gneiss. The felspar and mica of these rocks are shattered to pieces, dissolved, or turned into clay; but the loosened quartz crystals may be blown about by the wind, or carried into the sea, there to form sandstones, or be washed up on the beach and blown inland by the first strong sea breeze. In districts poorly supplied with rivers the sand, as is well known, tends to accumulate in large quantities, usurping the place of vegetation. A special character belongs to this desert sand, and if we can learn in what respect it differs from marine sand, we shall see that the masses are influenced in different ways by the natural forces which operate upon them.

To Lancashire and Cheshire geologists any question affecting the structure of sand grains naturally possesses great interest, and the researches of Sorby, directed to a microscopic examination of the quartz grains now being rolled over one another on Cornish beaches, indirectly helped to explain the origin of some of the Triassic sandstones. It was found that whilst the larger grains of quartz liberated from the washings in the china-clay pits tended, after being for a long time the sport of the waves, to partly lose their angles, marine action seemed quite powerless to affect the minuter grains, which were constantly found to be angular. Losing one-third of their weight in water, the quartz chips roll over each other with correspondingly diminished force, while the finer particles are placed under still further disadvantage as erosive agents from their power of remaining longer in suspension, and consequent increased liability of being drifted out to deep waters by the retreating tide. The bearing of these

facts on Triassic geology is important. It is a fact, easily noted with a hand lens, that many seams in our local sandstones are built up almost entirely of quartz grains having well rounded outlines. The question then forces itself upon our minds as to whether some agency other than marine action has not been concerned in giving this peculiar form to the grains. Are there any other masses of well-rounded sand grains found on the earth, and under what conditions are they found to exist? In seeking for an answer to these questions, we shall be led to study the effects of wind erosion, as carried on by the "sand-blasts" of nature, and as probably influencing the deposition of some red sandstones in a bygone period.

The author then referred to Prof. Phillips's researches into the constitution of the desert sands of Arabia, which were found to be made up of grains almost uniformly well rounded. This fact, he continued, suggested a question as to how the grains had acquired their round form. Certain conditions prevailing near Liverpool—on the New Brighton shore—seemed to furnish a solution to the question. Fragments of stone, slate, shells, &c., left on the New Brighton beach for any length of time, just beyond reach of the tides, were found to be polished and bevelled by the erosive action of grains of sand pelted against them by the westerly winds. (Some fragments of limestone from Stackpole, Pembrokeshire, were here exhibited, in each of which the outline was distinctly conical in one direction, having been bevelled by blown sand.) These illustrations helped them to understand the gigantic nature of the work going on in such a country as Egypt, where the abraded surfaces of the Sphinx and other monuments testified to the wonderful power which the natural agent they were studying might exert upon rocks—wherever these were exposed—in a rainless district, and this constant rubbing against rocks and hitting against each other must have an equally powerful effect in subduing the angles of the grains themselves, so that they tended to become round in form.

Much of the loose sand of Egypt and the Soudan would ultimately be blown into the Nile Valley, to be carried from thence to the Mediterranean; so that it seemed reasonable to suppose that a considerable portion of the sedimentary accumulation at the mouth of the Nile consisted of well rounded sand grains. Inland seas, such as the Caspian and Sea of Aral, would be peculiarly liable to occupation by deposits of this character; and the result of further inquiry would probably be to show that the triassic inland sea received extensive contributions of desert sand, either carried directly by the wind, or indirectly through the water courses.

In the discussion that followed the reading of the Paper, Mr. C. E. Miles suggested that the fact of the triassic quartz-grains having been to some extent derived from the wear of pre-existing sandstones, might sufficiently account for their being occasionally well rounded; Mr. Mannington alluded to the power of the sand-blast as now employed in our manufacturing industries; and Mr. Thorp instanced the weathered rocks of Monument Park, Colorado, as being found in a rainless district, and surrounded by fine sand.

NOTES OF THE MONTH.

By the President.

On the 23rd of February, there occurred a series of shocks of earthquake, which caused great damage and loss of life in the Riviera. Less severe shocks have since occurred.

That the shocks of February 23rd extended to this country, was shown by registering instruments in Kew Observatory and in the Royal Observatory at Greenwich; but, as bearing on the limits of the disturbance, Father S. J. Perry, of Stoneyhurst College, Blackburn, writes to *Nature* to say that, on carefully examining his magnetograms on the day of the earthquake, he could find no trace of any special disturbance. It may be mentioned that a Member of this Association, Mr. Isaac Roberts, F.R.A.S., F.G.S., proceeded to Nice a day or two after the earthquake, and made many observations

respecting it. Students of geology will do well to carefully collect and examine all reliable evidence respecting such occurrences.

In the month of January a large mass of the Table Rock, at the Falls of Niagara, estimated to have measured 150 feet long, 60 feet wide, and 170 feet deep, fell into the river.

An important geological discovery has been made on Jackatoo Island, Sydney, in the shape of a Mastodonsaurus. This is the first Labyrinthodont found in Australia.

A discovery of a large deposit of Celestine has been made at Yate, in Gloucestershire, which, according to Mr. H. G. Madan, of Eton College, lies just below the sub-soil upon a bed of Triassic marl, which rests unconformably upon the coal measures just at the eastern edge of the Bristol Coal-field in that district. Analyses, made at different times in the writer's laboratory, show Gloucestershire celestine to contain from 94 to 96 per cent. of sulphate of strontia, with 1 to 2 per cent. of sulphate of baryta, less than 1 per cent. of sulphate of lime, and the remainder silica, with a little magnesia and oxide of iron and alumina.

With reference to the subjects of Blown Sand and Wind Erosion dealt with in recent papers before this Association, it is interesting to note that operations, now proceeding, to uncover the buried portion of the Sphinx, have resulted in bringing again to light a fine flight of steps, which, although uncovered in 1817, have been hidden for the past seventy years by an accumulation of drifted sand. Other structures now covered by sand will, it is expected, be opened out. This subject of blown or drifted sand deserves more attention than is usually given to it.

Those who are interested in the study of Meteorites will do well to note, either in the American Journal of Science, vol. 32, or in the abstracts from that journal, contained in the Journal of the Chemical Society of London for February, several analyses and descriptions of meteoric masses from different localities.

L. Bourgeois, a French chemist, has succeeded in producing crystallized insoluble carbonates by first heating amorphous carbonates in a tube at 150 to 180° C., with water and chloride of ammonium, and then slowly cooling, and after this process of heating and slow cooling has been repeated four or five times, the carbonate completely crystallizes. He also obtained similar results by heating the carbonates with solution of urea at 140° C. He has obtained by these processes calcite in simple rhombohedrons without admixture with arragonite; strontianite in short rhombic prisms; witherite in long thin fibrous needles; cerussite in long striated needles; cadmium carbonate in rhombohedrons similar to calcite; copper carbonate in small prisms, which seem to be identical with malachite.

At the Annual General Meeting of the Geological Society of London, on February 18th, the President, Professor J. W. Judd, F.R.S., &c., delivered, as the anniversary address, an eloquent discourse on "The Relations between Geology and the Mineralogical Sciences," in the course of which he stated that no definition of *life* which has yet been proposed will exclude the kind of processes which we can now show to be continually going on in mineral bodies, and that it is of the first importance that we should clearly recognize the fact that the distinctions between living and non-living matter are not essential and fundamental ones; that cycles of change, exactly similar in almost every respect to those occurring in the animal and vegetable kingdoms, are equally characteristic of the mineral kingdoms; though in the latter they are more difficult to follow, on account of the extreme slowness with which they take place. He added that when this great truth is fully recognised, the separation of the biological and the mineral sciences will be at an end, and mineralogy will begin to profit by that revolution in thought and in method which has already done so much for her sister sciences. Speaking of mineralogy as in the "pupa-stage" of its development with its methods imperfect, he predicted for that science a

great future, and showed how in many ways it can prove of the greatest aid in solving geological problems, whilst, on the other hand, it can itself derive important help from geological science. The whole address is so suggestive of further methods of inquiry, that it can scarcely fail to incite workers to action in many directions.

One of the most important of recent contributions to Geological literature is the second volume of Professor Sterry Hunt's Geological and Chemical Essays, entitled "Mineral Physiology and Physiography."

Another excellent work is a new volume (58th) of the International Scientific Series, by Professor A. Heilprin, on "The Geographical and Geological Distribution of Animals."

As having reference to a subject dealt with at one of our recent meetings by Mr. Isaac E. George, it may be mentioned that there has lately been published "Géologie de Jersey," Par Le P. Ch Noury, S.J., which contains a carefully prepared coloured map, and an elaborate detailed description of the geology of the island.

Students of geology resident near or visiting Oxton, should watch closely the many fresh exposures of rock surfaces now taking place, owing to the activity of builders and road makers. It should be remembered that only last year Dr. C. Ricketts, F.G.S., was successful in finding in this neighbourhood many fossil footprints and other markings, and that in previous years Mr. G. H. Morton, and other local geologists, have made, in this locality, many discoveries of importance.

And whilst writing of new exposures in this neighbourhood, it may be well to ask the members of the association to watch carefully all operations that may bring to light new geological features in our district, and communicate them without delay either in the form of a note or paper, or by sending particulars to the Secretary, so that other members may make observations.

MUSEUM VISIT.

Lecture on Silica Minerals.

On Saturday, March 19th, a demonstration was given by Mr. C. E. Miles, at the Museum, William Brown Street, on the forms of Silica. Commencing with the commonest species, Quartz, Mr. Miles described the crystalline forms under which it was known, with the varieties arising from the presence of various colouring matters. He then passed on to consider the species of Silica—such as Agate, Jasper, Chalcedony, Opal, and Avanturine—which have a varying percentage of water or other foreign substance in their composition, and are frequently of stalactitic origin. The circumstances giving rise to precious varieties of Silica having been pointed out, a discussion ensued as to the part taken by heated water in developing minerals in the fissures and other hollows of rocks.

Specimens illustrative of Mr. Miles' remarks were examined as they lay in the cases forming part of the Phillips collection of minerals, and the educational value of the series generally was strongly insisted on by the President in supporting a vote of thanks to Mr. Miles for the lecture.

ORDINARY MEETING,

Held at the Free Library, Monday, April 4, 1887, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the chair.

Nominations.—Mr. Wm. Harvie, 110, Kirkdale Road, Mr. Thos. D. Roberts, 19, Creswick Street, and Rev. E. Hicks, 22, Erskine Street.

Donations.—"The Geographical and Geological Distribution of Animals," by A. Heilprin, *presented by the President;* "The Lepidopterous Fauna of Lancashire and Cheshire," part 4, by J. W. Ellis, L.R.C.P., *presented by the Author.*

Exhibits.—Several specimens of paving stones with report of their chemical composition; Microscope, with petrological slides; Magazines, Maps, &c., were on view for an hour

previous to the meeting, so that members had an opportunity of examining them more leisurely than could have been done during the meeting.

A Paper was read on

NOTES ON THE ACTION OF WATER IN REGARD TO MINERAL AND ROCK FORMATION,

BY H. T. MANNINGTON.

(ABSTRACT.)

Among the agencies at work in modifying the crust of the earth, the action of water in its various modes of operation occupies a principal place. We find that its presence is universal, and that in the constitution or production of probably every natural product it has been a potent factor. Chief among the remarkable qualities of water is its great solvent power—exceeding that of any other liquid—which is the occasion of our not finding in nature what may be termed absolutely pure water. All rain contains a variable amount of carbonic acid, ammonia, &c., and this is of enormous influence in the breaking down of rock masses, and the solution of alkaline silicates, &c., as well as in many reactions which take place through the agency of percolating waters. This solvent power is enormously increased at a high temperature and a correspondingly increased pressure, such as we know to occur in the more interior strata of the earth's crust, under which conditions it is not only most powerful as a solvent, but also in its chemical action.

Daubrèe found that "at 750° F. common glass—a silicate of lime and alkalies—in presence of water swelled up and was transformed into an aggregate of crystals of wollastonite (silicate of lime), much of the silica separating as quartz." This is a striking instance of chemical action at a high temperature, and in a comparatively short time; but not less remarkable effects may be produced by water at very much lower temperatures, when the action is more prolonged and the volume of water greater. It is difficult to realise the

condition of the water in the more interior parts of the earth's crust, as the heat must be enormous and the pressure likewise, probably in many cases there is a state of igne-aqueous fusion. We have abundant evidence of its presence in volcanic discharges, hot springs, &c., and we know what an enormous power for the transmission of water is capillarity, in addition to which we have the saturation of the ground by surface water continually descending; so that, in all probability, the rock masses of the earth's crust are fully charged with water even to the depths of the deepest seas. When we remember the expansive power of water and of superheated steam, we need not be at all surprised at earthquakes, &c., resulting from its sudden intrusion to heated surfaces, possibly through fissures. Water itself expands greatly at high temperatures, and the occurrence of red-hot water was recently described by Dr. Hurter.* The volume of water circulating through the rocks is enormous, the capacity of absorption varying from 0·37 per cent. by weight in granite, up to 20 per cent. in chalk, and 24 per cent. in clay. †

Mr. Isaac Roberts, F.G.S., has given the results of experiments on the sandstone of this neighbourhood, in a valuable paper to be found in our Transactions ("Triassic Sandstone," Transactions, vol. iv.); and Prof. Prestwich ("Underground Temperature"), among several other instances, states that, in the Gwennap district of Cornwall, where 5,000 acres were combined for drainage purposes, no less than twenty million gallons of water have been pumped per twenty-four hours, from a depth of 1,200 feet. At present some fourteen million gallons are being pumped from the works of the Severn Tunnel per twenty-four hours. The action of heat, coupled with this universal water, is an active agent in effecting the metamorphism of rocks, and is quite sufficient to account for the variety of strata which may be produced from mud and clay, limestone, shale, sand, or volcanic ash, and it is evident,

* Jnl. Soc. Chem. Ind., 1884, p. 69. † Geikie "Text Book," p. 299.

as remarked by Geikie,* that the "study of metamorphism leads us from unaltered stratified deposits at the one end into true eruptive masses at the other." The mode by which potash, silica, &c., are retained by surface soils and sedimentary deposits when traversed by waters holding alkaline salts in solution—these same materials being necessary for the growth of plants—is described by Mr. Miles in his paper on "Mineral Springs." † It is very important in its bearing on this subject, and shows how we may get the great strata of gneiss and schists, and, in all probability, some granite. It seems extremely probable that we may not only have true volcanic granite, but true metamorphic granite also, although Mr. Semmons ‡ seems to think that most of the evidence is in favour of a purely igneous origin.

Professor Judd has "every reason for believing that the schists and gneisses of our Highlands and Scandinavia have resulted from crystallizing forces acting upon strata of sandstone clay and limestone, or upon igneous material." § Water has, doubtless, been an active agent in such cases in producing the separation of many crystals; of the layers of mica, &c., observed in the cleavage of foliated rocks, the foliation itself, no doubt being often produced by great pressure and by hydro-thermal agency as shown by Daubrèe. The greater deposition of various minerals along cleavage planes may be due to their allowing freer passage for water or steam, as is obviously the case with joints and fissures, but one cannot readily account for the formation of crystals, such as those of iron pyrites, which are so common in schists, slates, &c. It would appear to be some polar or molecular force, some mutual attraction which brings the similar particles together. Daubrèe says,‖ in referring to the minerals (Zeolites, &c.) found in and about the ancient masonry at Plombieres, and Bourbonne-les-Bains, "it is in general a small part only of the minerals

* "Text Book," p. 308. † Transactions, vol. iv.
‡ "Structure, &c., of Granites," L'pool Geol. Soc., 1879. § Brit. Assoc. Address, 1885. ‖ Geologie Experimentale, p. 218.

developed which is brought by the water; the other elements pre-existed in the rock, and apparently obedient to an 'energetic tendency' to crystallize, they seize in some way upon the first elements they meet according to their affinity."

This is doubtless the case, but what is the "energetic tendency?" Professor Judd, in his recent address to the Geological Society,* declares that he knows of no essential difference between the growth of a mineral and that of a plant or animal. They certainly are alike in this, that the growth of each is dependent upon laws of which we know little or nothing. In the one case we see the results of what we term inorganic chemical affinity, and in the other of the forces of life, and both causes may possibly be again reduced to the great law of adaptation to environment, but beyond that we cannot go. The formation of crystalline rocks from sedimentary strata by the aid of circulating waters is of great interest; silica and potash are retained, lime, magnesia or soda given in exchange; a great variety of re-actions may then take place, the general result being to produce a soluble soda salt, together with insoluble silicates of lime and magnesia, sulphate of lime, dolomite, &c.† The chief cementing materials of such rocks as sandstones, grits, &c., are carbonates of lime and magnesia, together with silicate, oxide, and probably carbonate of iron, and also silica itself. These are brought or made effective by means of circulating waters, and such examples as a piece of sandstone from the non-coherent sand banks or cliffs at Ramsey, Isle of Man (exhibited), containing 37 per cent. carbonate of lime, illustrates the process perfectly. The cementing material may also be carbonate or sulphate of baryta, or sulphate of lime. Sulphate of baryta occurs in some sandstone beds near Nottingham as a cementing material,‡ and also in the millstone grit of Grimshaw and Houghton's delph.§ In this rock (specimen exhibited of mill-

* "Nature," vol. xxxv, pp. 392, &c. † Hunt "Chemical and Geol. Essays." Bischof, "Chemical Geology." ‡ Prof. Clowes, British Association Report, 1885. § "Transactions," vol. iii, p. 149.

stone grit), the cementing material is chiefly carbonate of lime and magnesia, and in joints may be found deposits of dolomite. It contains also a good deal of iron in combination as a ferrous salt; and it is frequently the case that a white sandstone contains much more iron than a red one, at the same time usually containing more carbonate of lime or magnesia than is the case with the red. The action of water containing organic acids or carbonic acid upon sulphates in the presence of iron salts, frequently results in the production of iron pyrites, and it is to this reducing power of such water that the iron disseminated through the rocks is brought into solution, and then subjected to various reactions, the final result being usually an oxide, sulphide, or carbonate of the metal. This is also the case with manganese; the agency of organic matter is perfectly evident in the production of many deposits of that ore, notably in the case of the nodules dredged by the "Challenger" from the deep sea bottom, and by Mr. Buchanan from Loch Fyne and elsewhere; * in fact, oxide of manganese appears to have followed in many cases almost exactly the same lines in its course of solution and deposition as oxide of iron.

All the evidence in connection with the deposits of iron pyrites seems to point strongly to their having been the result of aqueous action. The great deposits in Spain, and the various instances cited by the writer in a former paper,† all support the idea that they are of the nature of "segregated" veins.

The solubility of carbonate of lime in water containing carbonic acid has been of enormous importance in the formation of mineral deposits, not least in the hollowing out of large cavernous spaces in limestone strata, such spaces afterwards serving for the deposition of many minerals and ores, *e.g.* the hematite deposits of Cumberland, and many rich mines in Nevada, &c. These hematite deposits have no doubt been

* British Association Report, 1881. † Iron Pyrites, "Transactions," vol. ii.

derived from solutions of iron brought from the surrounding measures by water containing CO^2, lime has probably replaced the iron, which has then been thrown down either as oxide, or as carbonate, which has been afterwards altered.

Mr. Lebour * mentions some small earthquake shocks experienced at Sunderland, and which he attributes to the closing in of faults or cavities, produced by water in the limestone strata upon which the town stands. Referring to the solution and denudation of limestone, the writer objected on various grounds to the theory of Mr. Mellard Reade, F.G.S.,† that the deposition of limestone was at no time carried on at a greater rate than at present, and expressed the opinion that at one time it was more rapid, and that the atmosphere also contained more carbonic acid than is the case now, such deposition, as also that of the coal, serving to prepare the way for a more abundant terrestrial animal life. The production of many mineral veins has no doubt been often brought about by the substitution of lime for various metals, when solution of these come in contact with calcareous strata :—*e.g.*, certain veins in Derbyshire containing lead and copper which traverse alternate beds of limestone and basalt. The ore is plentiful where the walls of the rent consist of limestone, but reduced to a mere string where they are formed of basalt. ‡ The curious facts of the general association of certain minerals in lodes are, no doubt, also due to questions of solubility and replacement, as *e.g.*, the sulphides of iron and copper together, lead and zinc, tin and wolfram, and various other instances. The subject of these notes is a very vast one, and the writer has only touched the fringe of it in a few points. The solubility of silica and its bearing on the constitution of rock masses; the deposition of sulphates of baryta and strontia; the occurrence of oxide of manganese under similar aqueous conditions to oxide of iron; the action of steam on metallic sulphides

* British Association Report, 1885. † "Chemical Denudation." ‡ Lyell "Elements."

giving rise to sulphuretted hydrogen; the presence of water of crystallization in minerals; the efflorescence of various salts, and the many phenomena of mineral springs; all these things and many others make up an amount of material upon which volumes might be written. It is, however, of the utmost importance in the understanding of rock masses, that we should be acquainted with the influence upon them of the forces to which they are exposed.

The Alchemists of old believed that water was the first principle of all things; it certainly appears to be more or less connected with all physical change, and no doubt will continue to be

"Until this outworn earth
Be dead as yon dead world, the moon."

EXCURSION HINTS.

As announced elsewhere, our friends will see that a new feature has been introduced into our monthly gatherings. Specimens collected at our field meetings, or during the holidays of individual members, can now be brought to the room and laid on the table at 7 p.m. This enables them to be leisurely examined for a full hour before the ordinary business of the meeting commences. Photographs, sketches, and scientific periodicals likewise claim the attention of any who care to drop in to have a look at them.

Our Excursions have once more commenced, and what we mainly require to ensure their success is a good attendance. But this cannot be secured unless each member makes it a matter of personal concern. So long as an Executive is entrusted with the work of organising trips, it becomes a matter of duty for each member to put in as many attendances as possible.

We also want our working bees to look about them during their summer rambles, and let us know if they come across any neighbourhood of sufficient interest to furnish materials

for a field meeting at some future time. There must be several such places not yet visited by the Association in the Lancashire coalfields, in Derbyshire, South-east Cheshire, and Flintshire, or along the Welsh Coast as far as Penmaenmawr. We hope that the lessons learnt at past excursions will prove highly useful to hammerers when they take their annual run into the country. What was gleaned in a hurried run over the Wrekin, or Crags of Deganway, would be eminently serviceable to the geologist who has decided to take Castleton or Ambleside as a centre, and to devote a few days to working over the volcanic rocks. And he, or she, who has gathered limestone fossils under our guidance at Llangollen, will know in what situations the same are to be looked for near Matlock and Buxton. Every use should be made of our library, with its geological maps and monographs, and no one should neglect to obtain from our secretary before starting, any available hints as to the geology of the district to which a holiday tour is contemplated. May the season's work result in a plentiful harvest of weighty bags and blunted chisels.

I. E. GEORGE.

NOTES OF THE MONTH.

There has lately been opened in the Natural History Museum, Cromwell Road, South Kensington, a gallery of the palæontological department, in which along with other collections is placed that of William Smith, who has been called "the father of English Geology," and who died in 1839. William Smith, whilst engaged between the ages of 18 and 22 as an assistant to a land surveyor, assisted in surveys in Gloucestershire, Worcester, Warwick, Oxford, and Herefordshire, and owing to acquaintance with farming operations gave much attention to the different kinds of soil. He was afterwards engaged as surveyor and engineer in connection with the Somerset Coal Canal Company (the canal was commenced in 1795), and devoted much time to "the

identification of strata by the organic remains found imbedded therein," and to show to others that his stratigraphical views were correct, he commenced the collection of fossils arranged stratigraphically, and these he terms "Vouchers." After 1799 he had many engagements in land surveying all over England, and this much extended his collection. In 1794 he made a tour of 900 miles from Bath to Newcastle by one route, returning by another, and the information gained then and at other times led to the production of a small geological map of England in 1801, he having previously prepared a map of the neighbourhood five miles round Bath. In 1802 his collection was arranged for inspection at Bath. In 1804 it was removed to 15, Buckingham-street, Adelphi, London, and in 1816 it was purchased for £500 for the British Museum. A further sum was afterwards allowed for additional specimens. For the last half-century it has not been seen as a collection, but it now occupies a suitable position in the gallery before mentioned, and is well worth examination.—A.N.T.

On March 29th, died Robert Bostock, of Birkenhead, an earnest, devoted practical geologist, whose papers and remarks at the meetings of the Liverpool Geological Society and elsewhere always commanded attention by reason of their thoroughly thoughtful and practical character. He was a man imbued with a true love of science, laborious and earnest in his studies, and thoroughly conscientious and truthful in describing the results of his researches and the conclusions he drew from them.—A. N. T.

A new periodical, "The Wesley Naturalist," the monthly journal of the Wesley Scientific Society, is devoting a portion of its columns to communications on geological subjects. The first and second numbers (for March and April) contain articles on the Laurentian and Cambrian strata, Physical Geology, Graptolites, and Coal plants. One valuable feature in the work of this society is the circulation amongst the members of specimens with descriptive notes, the specimens &c., being arranged

by "referees." Other branches of science are dealt with in a similar manner.—A.N.T.

A Honolulu newspaper just to hand contains some very graphic accounts of the recent eruption of lava from Kilauea, in the island of Hawaii, written by eye witnesses; one describes the lava "boiling in the craters," and being thrown up, "tons at a time," 50 to 100 feet in the air, as if by a powerful jet of gas or steam passing through the mass, and speaks of a lava stream descending the mountain side like an open river 150 to 200 feet wide, moving at the rate of six to eight miles an hour. The lava did not appear to be perfectly fluid, but seemed filled with lumps or grains, with occasionally great thick black lumps floating on its surface.—D.C.

A short time ago an excavation made at the north end of Hope Street showed the rock there to be the soft yellow sandstone which is familiar to us as the upper beds of the upper Bunter. A similar exposure was seen in Caledonia Street also; both these streets appear in the Geological Survey maps in a strip coloured as water-stones in the lower Keuper division. The relation between these two divisions was not shown in these exposures, but a section exposed in Upper Parliament Street in 1882, and which was noted at the time without any reference to maps or other sections showed a fault crossing the street, just in front of house No. 46, in that part of the street between Parliament Place and Percy Street, having on the west side red and grey shale, and on the east side soft yellow sandstone; no fault is noted at that place on the Survey maps. It is clear, therefore, that notwithstanding the general accuracy of these maps, much information in regard to detail is still required, and, so far as Liverpool is concerned, this can only be obtained by carefully noting all exposures that may be made in our streets.—D.C.

A new book, lately published by Messrs. Macmillan & Co., "Palæolithic Man in North-West Middlesex," by J. A. Brown,

should prove of much value to geologists studying that particular district. It would be well if other districts could be dealt with in a similar manner.—A. N. T.

"Nature," April 14th, contains a graphic description, taken from March number of "American Journal of Science," of a meteoric mass seen to fall near Mazapie, in Mexico, on November 27th, 1885, during the periodical star-shower of the "Bielids." The fall was accompanied by a hissing noise, followed by a loud thud, whilst round about there was a strong phosphorescent light, and luminous sparks were suspended in the air, such as those from a rocket. Immediately afterwards there was found a hole in the ground, and in it a "ball of fire." Fearing it would explode, the persons present retired to a distance, and on returning after a little while, found in the hole a "hot stone," which they could barely handle, and on the next day it looked like a piece of iron. The weight of this mass was 10 pounds 4½ ounces troy. A chemical analysis showed it to consist of Iron 91·260, Nickel 7·845, Cobalt 0·653, Phosphorus 0·300. Carbon and Chlorine were also detected. —A. N. T.

At a meeting of the Geological Society (London), held March 9th, 1887, Professor H. G. Seeley, F.R.S., F.G.S., described some fossil bones which are in the Fox collection at the British Museum, and have hitherto been regarded as belonging to some species of Pterosaur, from the Wealden bed, but which the author considers to belong to a true bird of a lowly form approximating more to the Dinosaurs than any other Avian type hitherto described. It is named Ornithodesmus cluniculus.—D. C.

EXCHANGES RECEIVED.

Journal of Liverpool Astronomical Society, March and April; Transactions of Leeds Geological Association, part 2; Transactions of Manchester Geological Society, vol. xvii., parts 8, 9 and 14, vol. xviii., part 3, vol. xix., parts 3, 4 and 5; Transactions of Liverpool Engineering Society, vol. vi., 1885; Annual Report of Yorkshire Philosophical Society, 1886; Annual Report of the Committee of Liverpool Free Library, 1886.

FIELD MEETING.

On Easter Monday, April 11th, the first Field Meeting of the season was held in the neighbourhood of St. Helens, under the guidance of Rev. S. Gasking, B.A., F.G.S. On leaving St. Helens Station our first visit was to Cowley Hill delph, passing over the fissile yellow sandstone which in places cropped out at the surface. At Cowley Hill one seam of coal was seen in the quarry with its accompaniment, the underclay; few fossils were found here. Our next visit was to Middlehurst's quarry at Crank, locally known as the *Red Cat.* The rock here is a micaceous sandstone of fine texture, which is worked for building purposes. One very thin seam of coal was observed, and an old disused pit; the only fossils found here were Serpulæ on a few slabs; some rain pittings were also seen.

Leaving this district in the lower coal measures to return to St. Helens, which sits on the middle coal measures, it was clear that, as the lower beds formed the hilly country and the upper beds occupied the valley, that they must be separated by a fault, which was duly sought for, and, though not seen in section, its position was noted and its course traced for some distance.

A visit was next made to Doulton's delph, in which a number of coal seams could be seen on three sides of the quarry; Stigmaria passing into the underclay and one fine trunk of Dadoxylon were seen *in situ.* Fossils were found in abundance, and many collections were enriched by the specimens brought from that quarry.

ORDINARY MEETING,

Held at the Free Library, Monday, May 2nd, 1887, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the chair.

MEMBERS ELECTED.—Messrs. W. Harvie and T. D. Roberts and Rev. Elgar Hicks.

NOMINATION.—Mr. Richard H. Jones, 17, St. George's Hill.

Donations.—Official Year Book of Scientific and Literary Societies, 1886, *presented by the President;* Abstract of the Proceedings of Geological Society (London), Nos. 502, 503, *presented by Mr. G. H. Morton, F.G.S.*

The following were presented by the Government Department of Mines, Victoria, per Mr. Allen S. Caine:—"Observations on the Occurrence of Auriferous Ores in Hungary;" "Report of Progress of the Geological Survey of Victoria," Nos. 2, 3, 4, 5, 6 and 7; "New Vegetable Fossils in Auriferous Deposits of Victoria;" "Report of Mining in California and Nevada;" "Mineral Statistics of Victoria, 1885;" and "Annual Report of Secretary of Mines."

Exhibits.—Microscopes, with sections of coal measure plants—the President; Photographs and rock specimens from Devonshire—Mr. George; Minerals from the Isle of Man—Mr. Marrow; Fossils from Doulton's Delph, St. Helens—Mr. Clague; Fresh water shells from submerged forest, Leasowe—Mr. W. H. Miles; Volcanic dust from Krakatoa—Mr. C. E. Miles.

The following Paper was read by Mr. P. H. Marrow:—

A GEOLOGICAL RAMBLE IN THE ISLE OF MAN.

In all the valleys that I visited there is an alluvial deposit many feet thick, composed of sand and shingle, which leads one to suspect that the valleys, at least, were under water at no very ancient date; and I am informed that the valley gravels on the north of the Island contain shells such as tellina, venus, astarte, turitella, &c., all of which exist at present in the neighbouring seas. That the land has been subjected to upheaval within very recent geological time, is well shown on the shore line at Carrickey Bay, about a mile to the north-west of Poolvash, where the remains of a raised beach is seen in section, with its great rounded boulders of quartz and flat pebbles of schist, both being derived from the underlying rocks, torn up, rounded, and formed into a beach in some bygone day. This raised beach leads to some confusion when travelling south-east towards Poolvash, owing to its changing

character. At that place it loses all its characteristics as a raised beach, and appears as a conglomerate made up of quartz, chlorite schist, sand, and all the various mixtures that go to form a pebble bed. It stands 20 feet above the present shore line, lying directly upon the carboniferous limestone, and looking for the moment as if it belonged to the same period; and what makes it more genuine looking is a well of fresh water springing from it, but this well is a tell-tale, for its water is extremely hard, and is almost effervescing with carbonic acid gas (CO^2). This highly charged water running over the limestone and then into the raised beach has cemented its parts together, and converted it into the hard, compact looking conglomerate, which is not recognisable with the loose sandy continuation of the same bed a mile to the north-west of it. Although this seeming conglomerate is so old looking and deceptive, it is of modern origin, and was formed in the same way and by the same agencies as the bed that lies 20 feet below it, *i.e.*, on the present shore of Poolvash Bay. The fresh water, there, flows through the strata under the stile road from Castletown on to a platform directly over the shore, where it forms large pools. These pools in wet seasons overflow, run on to the beach, and break up the shells which lie in great numbers amongst the boulders and pebbles, cementing the stones and sand together for hundreds of yards along the shore, forming a solid barrier which protects the loose highlands behind from the action of the sea. This but wants a slight elevation and a little time to obliterate all traces of shells, and we have a second conglomerate formed, lying on the lower beds of the limestone.

Before leaving Poolvash I should like to call attention to the wonderful system of joints set up in the so-called Poolvash marble, (which belongs to the carboniferous limestone shale, and contains in fair abundance one of the lamellibranchs, known as the posidonia). The sides of the quarry where this stone is worked are perfectly vertical, and appear like a built wall, each stone of which has been squared. This apparently

built wall is in reality the jointing of the limestone, and is so regular, that with an iron bar and wedges it is possible to get blocks of limestone in great quantities of a uniform size. Lining each joint is a fine crystalline deposit of carbonate of lime and magnesia.

On the shore where this limestone is suffering denudation from the sea, the most fantastic shapes have been taken, the water having worked out the joints, leaving great pinnacles standing on stair-like pedestals, and massive rib-like masses more resembling igneous than limestone rock. That this joint structure is not merely due to shrinkage is very forcibly felt when viewing this limestone; the joints are smooth and have even surfaces, and divide up into blocks which roughly take the shape of rhomboids, and, as Mr. Godwin-Austen suggests, there would seem to be in these conditions an indication of the influence of something analogous to the force of a cleavage (not that resulting from pressure, as in slate rocks), but that which in crystallization causes the molecules of the crystals to group themselves in planes with surfaces of least resistance. This arrangement of the particles of the rock explains many of the difficulties which beset the shrinkage theory. That there are shrinkage joints there is no doubt, but the joints due to dessication and consolidation are usually short, are not arranged in sets by their parallelism, and rarely cross each other. They are not smooth in jointing, have no even surfaces, and their fracture or joint shows that the rock has been rudely torn asunder.

Underlying this limestone and coming to the surface a mile to the west of Poolvash, are a series of schists (probably) of silurian age, which are very interesting from a metamorphic point of view. The manner in which silica has entered into the composition of the schistose rocks is very instructive, and is found in the finer or more slaty varieties, arranged in thin laminæ. It also runs through the mass of rock in great veins and beds, and in some cases it has completely changed the character of the rock, altering the soft unctuous mass into

a hard gritty variety (closely resembling trachyte), which would be hard to recognise as an altered schist, unless the various degrees were seen. This silicious material appears to be an infiltration, and it is just possible that a replacement may have occurred, and is rather curious as showing that metamorphism may take place by the reaction of one material upon another by infiltration, probably under normal conditions, and throws no little light upon the formation of a great number of puzzles that are continually cropping up in relation to these metamorphosed muds. When viewing these schists *in situ*, the old theory of deposition of various materials in thin layers gets further and further away, and the chemical theory of exchange and reaction of materials upon each other is forced upon the mind, against all old teachings and preconceived ideas; and one almost comes to regard water as a kind of first principle whose functions and powers are necessary for every change and modification. That this ever active, universal carrying agent, water, finds its way into the most compact and unlikely materials, is beyond a doubt; but it does more than merely penetrate the very pores of the rocks, it exchanges the substances with which it is charged, with the various rock masses through which it journeys, barters with each the materials for which they have the greatest affinity, taking in exchange substances for which other compounds will likely exchange for something else; and so on, in this quiet, silent way, this ever active agent is altering and modifying the earth's crust, just as much as the storm, rain, and ice by denudation is remodelling its external portion.

In the old Neptune and Pluto school of geology, where we are taught to believe in two forces antagonistic to each other, viz., water, the leveller and reducer of land, directly acting as a mighty battering ram, undoing the work of the upheaval forces, is, I think, only true as regards mechanically acting waters. The chemical waters, if I may so style them, act in many cases in direct opposition to these hammering and denuding waters, by bringing about metamorphism, which

hardens soft clay-like rocks, especially if they contain alkaline bases combined as silicates, by taking from them soda, lime, &c., setting free the silica which forms with the remaining materials a rock which is better fitted to withstand the mechanical forces opposed to it. This is well seen at the chasms, Spanish Head, and on the south-west coast of the Island, where this metamorphic action is but local; the changed rock stands forward forming headlands, whilst the softer unaltered schists have been cut back for great distances by marine denudation.

FOXDALE.—On entering the Foxdale district it becomes hard work for the geologist, as everything is so broken up by the intrusive igneous rocks, and the amount of hill climbing is not encouraging, but the locality is full of interest, and is well worth a visit. On entering the lead mine, which is the chief attraction there, one is at once struck with the admirable system of water power used on the surface works, and with the scientific application of certain physical laws in the separation of the metallic ores from the matrix; whilst the intelligent and gentlemanly captain of the mine is quite a revelation, and a pleasant surprise to one who has previously only had dealings with Lancashire captains in the same capacity. On going down the mine the tortuous direction of the mineral lode is well seen, and that the vein is not the ordinary fissure or fault so often met with in Cornwall and Derbyshire, with their regular course in a given direction. The Foxdale vein ramifies in various ways, and makes getting down the mine no easy task. The metals are deposited between the igneous and metamorphic rocks; that is to say, an intrusive mass of what is locally termed granite has forced its way into the schists of the district, forcing them aside, and crumpling them up in all directions. This mass on cooling occupies less space, and the contraction of the granite has left an open space on all sides of it. Not only is the fissure left, but a joint structure is set up in the igneous mass itself. In this fissure, and in each joint of the granite, metallic ores have

been deposited from water. The galena or lead sulphide is what is worked, but the mine contains a great variety of minerals in greater or lesser quantities (notably carbonate of iron). As to how these mineral ores were deposited, whether as sulphates or carbonates from thermal waters, I must not speculate upon, but would refer you to papers read by Messrs. Miles and Mannington recently before this Society. I may just mention that, on analysis, certain lode waters contained, in solution, minerals which go to form veinstones and lodes, but the quantities of these substances are now, in all cases, probably reduced to a minimum. They still serve to indicate the agencies which were once at work on a larger and more active scale in depositing mineral veins.

The effects of weathering and replacement are wonderfully well brought out at Foxdale. As I have before stated, the metals are deposited between the igneous and sedimentary rocks, but the changes that have taken place in the lode since it was first deposited are of the most complicated description. The granitic mass itself has undergone decomposition, and is so rotten that it breaks up into a fine powder on coming into the air; the decomposed portion is pure white, and contains little if any iron; whilst the undecomposed igneous rock is dark green, and contains great quantities of iron. There is very little doubt that the great quantity of iron removed from this decomposed granite is represented by the beds of carbonate of iron lying over and intermingled with the lead. In many cases the lead has been entirely replaced by the carbonate of iron, the iron forming in pseudomorphs after galena; in other cases nothing remains of the galena but its shape, and in its place we have a light porous material composed of iron, manganese, calcium, magnesia, and carbonic acid; whilst various compounds of iron, magnesia, and carbonic acid are responsible for great quantities of lead. That this decomposition has been brought about by surface waters containing carbonic acid, acting upon the alkaline bases of the granite, and then the alkaline carbonates upon the lead sulphide, is more than

probable; and whilst we cannot always imitate the processes which have taken place, and under conditions impracticable with the means at our disposal, we know, at all events, the resultant minerals, although we may be ignorant of their evolution. Combinations, stable under their normal conditions, are often no longer so when brought under the action of surface waters, when they undergo changes which are within the reach of our experience, and within the grasp of our means of research. We can thus see how from a few simple primary minerals the great variety of secondary minerals have resulted; minerals slowly evolved during long processes of change, and taking as they separate out definite crystalline forms of great beauty and infinite variety. There are also minerals which, under the influence of the surface waters, have been dissolved and removed, and their place filled by other mineral matter brought down by the same waters, which effect the destruction of the original minerals, whence has resulted a variety of the curious pseudomorphs known to mineralogists.* Such are some of the changes to be studied at Foxdale, where each and every cavity placed under these abnormal conditions contains treasures of beauty and interest to the geologist and chemist, some of which are rare, even at Foxdale (for example, the cockscomb-pyrites, fahlerz, feather-ore, &c.), and are only obtained in small quantities, but they are of exceeding interest when studied under the head of mineral evolution, and tell the thoughtful student that he "must first forge a key in a furnace of his own heating," before he can hope to unlock the cabinet which contains the secrets of Nature's laboratory.

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* Prof. Prestwich.

HINTS FOR HOLIDAYS.

It would be well if amateur geologists, in taking their holidays, would not only seek to enjoy their leisure, but make the most, geologically, of their wanderings.

The fact cannot be too strongly insisted on, that there is no spot on earth which is not geologically interesting; still, it is well for those whose time is limited, to devote special attention to those places where many interesting features are crowded together; and we propose in these notes to indicate occasionally such localities as will prove at once pleasant holiday resorts, and afford to the geological student opportunities of verifying for himself his class studies, and for still further advancing his knowledge.

Such a place is Scarborough, which is easy of access from Liverpool, a favourite resort for health and pleasure, and is situated on a part of the Yorkshire coast in the very middle of a very interesting series of rocks, all well exposed in shore sections.

We would strongly recommend any student intending to work in this district, to first pay a visit to the Scarborough Museum, where he will find a diagramatic view of the coast from Flamborough to Redcar, coloured and described geologically; and in the cases he will find a good collection of local fossils systematically arranged. By taking copious notes much information will be gained, which will be found invaluable in subsequent field work.

Next the cliff upon which the castle stands deserves special notice, as in it the coralline oolite, calcareous grit, Oxford clay, Kelloway rock, cornbrash, and some beds of the great oolite are seen in succession.

Turning southwards various members of the oolite formation may be visited in turn on the shore towards Filey and on to Speeton, where a dark coloured clay with marine shells constitute the northern equivalent of the Wealden clay of the south. This is succeeded by the red chalk and that by the white chalk, which is well represented at Flamborough Head.

Leaving Scarborough and passing northwards, the Lower Oolite and Lias formations may be studied, as these crop out at accessible spots on the shore; amongst which should be noted Robin Hood's Bay and Whitby; and, if time permit, the Middle and Lower Lias may also be studied on the shore further north, on to Saltburn and Redcar.

Needless to say, these rocks are full of fossils, and the palæontologist will find all along this shore a rich storehouse of knowledge. Of course the well-known family of the ammonitidæ is well represented, but it would be well to make diligent search after the gasteropodæ, new species of which have been found in the Lias of Northamptonshire.—D. CLAGUE.

MONTHLY NOTES.

BY THE PRESIDENT.

In a communication to the Academy of Sciences, Paris, lately read by M. Venukoff, on the Upheaval of the South-west Coast of Finland, the author alluded to topographic surveys lately carried out in Finland, which showed that the shores of the Baltic are continually rising. Since 1810 fifteen islands have become peninsulas, and many shallows have become islands or beaches, whilst on the South-west Coast and the Alan Archipelago, many places are now grazing grounds, market gardens, or cornfields, which a few years ago were under water. Steps are being taken to determine with certainty and accuracy the progress of this geological phenomenon.

In "Science Gossip," Mr. C. N. Barham describes a landslip which took place at Burton Bradstock, on March 11th. The strata, inferior oolite, consisting of sand intercalated with thin bands of shelly ragstone, resting conformably upon the upper lias, having in all probability been affected by the rains and frosts of an unusually changeable winter, had slipped away from its intractable base, burying upwards of an acre

of the neighbouring beach. Numerous interesting fossils were thus exposed, including various genera of the Brachiopodæ, Cephalopodæ, Conchiferæ, Echinodermatæ, Gasteropodæ, and also many well preserved fragments of Monocotyledonous wood.

The chemical examination of the volcanic ash from the eruption of Cotapaxi is stated by J. W. Mallet, in the "Chemical News," to contain silver to the extent of one part in 83,600 of ash. Although this quantity is small in proportion to the other constituents of the ash, yet it must have been very considerable when the vastness of the mass of the volcanic ash is taken into consideration. The sample was collected at a point 120 miles of Cotapaxi, where the ash had fallen to the depth of several inches.

A particular description of talc, known as *agalite*, obtained from New Jersey, is said to be largely used in paper making in place of kaolin, and it is stated that the high glaze of American paper is largely due to the use of this mineral. It is chiefly a silicate of magnesia. In colour it is almost pure white. It is of a highly fibrous character, insoluble in water, and greasy to the touch.

Professor H. G. Seely, F.R.S., of King's College, is again organising a field class, including beginners and advanced students, for the study, this summer, of geology near London. Such practical classes are of very great value, and it is to be hoped that many others of a similar character will be held in other parts of the kingdom. As regards Liverpool, it may be mentioned that it is intended, in connection with the "Liverpool Science and Art Classes," to hold a class for field work during the ensuing summer, which will be under the care of our Hon. Sec., Mr. Clague.

Amongst the recent additions to our Library, the reports, &c., presented through Mr. Allen Caine, by the Department of Mines, Victoria, are specially worthy of mention. Although

they deal with a district far removed from us geographically, they contain so many points of general interest that a reader cannot fail to obtain from them much important information that can be made serviceable in studying the geology of districts nearer home.

Amongst the new books lately published there are two which may be mentioned, namely, a new edition of "The Geology of England and Wales," by H. B. Woodward, published by Philip & Sons, of London and Liverpool, and a "Handbook of Historical Geology," by A. J. Jukes-Brown, published by George Bell & Son, of London.

Those specially interested in mineralogical matters will find some remarks of interest and importance as regards the estimation of the hardness of minerals in a paper by Mr. Thos. Turner, F.C.S., reported in the "Chemical News" of April 22, 29, &c., vol. 55. The different methods of testing hardness, and the various scales drawn up by different operators, are dealt with and criticised; an enlarged "Moh's scale" being given on p. 195. It is pointed out that tenacity may interfere with a correct estimation of hardness, and various forms of apparatus for testing purposes are described, the best being, apparently, those in which a steel or diamond point at the end of a beam or lever provided with sliding weights is used to produce a visible scratch, the weight necessary being, of course, proportional to the hardness. The paper, although dealing more particularly with the hardness of iron and steel, yet contains several points of use to the mineralogist.—H. T. MANNINGTON.

EXCHANGES RECEIVED.

"Report and Proceedings of Manchester Scientific Students' Association," 1886; "Tenth Annual Report of Lancashire and Cheshire Entomological Society," 1887; "Transactions of Manchester Geological Society," Nos. 6 and 7; "Annual Report of Smithsonian Institution," vol. 2, 1884.

VISIT TO CHESTER.

On Saturday, May 14th, a meeting was held at Chester, with the special object of inspecting the new museum of the Chester Society of Natural Science. Under the guidance of Mr. Shone, F.G.S., the party was conducted along the old walls and the banks of the Dee, and various features of geological and antiquarian interest were pointed out. At the museum much pleasure was derived from Mr. Shone's explanations of the various collections, especially the local antiquarian collection and one of fossil shells derived from the Boulder clay.

FIELD MEETING.

On Whit-Monday, May 30th, an excursion took place to Hilbre Island. The cliffs around Middle Eye proved very attractive objects of study in connection with marine denudation, &c., and the raised beach and Hilbre conglomerate had a fair share of attention bestowed upon them. The weather being warm, and the party a large one, everything passed off most agreeably. After tea an animated discussion took place as to the probable source of the material forming Hilbre rocks, and their position in the Triassic series.

ORDINARY MEETING,

Held at the Free Library, Monday, June 6th, 1887, Mr. H. T. Mannington, Vice-President, in the Chair.

MEMBER ELECTED.—Mr. R. H. Jones.

NOMINATION.—Mr. James Hornell, 105a, Grove Street.

DONATIONS.—Pamphlets on "Pebbles in Boulder Clay," by Dr. Ricketts, F.G.S.; "Notes on a Bed of Freshwater Shells and a Chipped Flint," recently found at the Alt mouth, by T. Mellard Reade, F.G.S., *both presented by the Authors*; Printed Forms for acknowledging donations to the Association, by the President.

A paper was then read, entitled

NOTES ON THE GEOLOGY OF DEGANWY AND ITS NEIGHBOURHOOD.

By T. Mellard Reade, C.E., F.G.S., &c.

In June of 1886 I stayed a few days in the neighbourhood of Deganwy, on the Estuary of the Conway, between Llandudno Junction and Llandudno, and, as is my wont, having nothing else to do, wandered about, picking up what information I could in an unpremeditated sort of way. I must therefore caution you that I am not going to give a systematic account of the geology of the neighbourhood, but only to impart a few facts and ideas that impressed themselves upon me in the course of my peregrinations.

The principal feature in the scenery immediately about Deganwy is a curiously isolated lumpy hill, on which is situated the ruins of Castell Diganwy. The form of this hill is well seen from the Chester and Holyhead Railway, between Conway and Penmaenbach Point. On referring to the survey geological map, which is confirmed on examination, it is seen to be carved out of felspathic trap, which is further stated to be contemporaneous with the Caradoc or Bala beds which surround it, but to this point I did not address myself.

In the escarpment of the Bala beds, S.E. of Deganwy, are several quarries, apparently in the position of the band of sandstones and calcareous beds marked on the survey map. They consist of alternating dark blue-black grits weathering to a dark purple brown. One section that I examined showed shales and sandstones dipping 53° South 20° East. Upon the face of the sandstone bed were slickenside striæ parallel with the dip of the bed. A joint plane was also to be seen, having a strike North 20° East, which appeared as if rubbed smooth by attrition of the beds. Another bed of sandstone in the same section showed a dip of 73° South 20° East, and was also striated with the dip.

A section of the West face of the quarry, having also a direction North and South, showed the alternation of sandstones and shales. At the South or escarpment end of the section

was a splendid example of downhill curvature of the beds, obviously produced by gravitation acting upon the disintegrated tilted beds, and bending them over in a terminal curvature. The phenomenon, which is really very simple, seems to have produced great wonderment with some geologists, who bring in the inevitable glacier to account for it, as for every surface feature of these latitudes which presents any difficulty of explanation. At the lower part of the section they become horizontal, and present the appearance of a rubble wall.

In a second quarry east of the one described I observed a joint plane striking due North and South, with slickenside striæ upon it dipping 18° South; also another further east, and parallel, with striæ thereon, dipping 6° North, or in the contrary direction.

A system of joints North and South, and another nearly horizontal, break up the beds into cubical blocks.

It is evident that the rocks have been pushed over each other, and the bedding planes ground together at right angles to the strike. The rocks have also been rubbed together at the joint planes. It would appear from this that there has been a movement of the rocks subsequent to the formation of the master-joint planes. There are, however, joints which only affect the individual beds.

One of the curious features in these rocks is the great abundance of carbonate of lime in the joints. It looks as if it had infiltrated from above. It does not cement the rocks together, but separates from them in plates, and altogether has a recent appearance. There is no doubt, whatever, that all these silurians were unconformably overlain by carboniferous limestone, an outlier of which forms the Great Orme's Head, and another the Little Orme. May not these infiltrates be a remnant of this covering now apparently all swept away by denudation?

The silurian rocks had been folded long prior to the deposition of the carboniferous limestone. Again, towards the

close of the carboniferous, further bending and folding took place, as evidenced in the long sweeping curves of the scarped beds of the Great Orme's Head. It is equally probable that the slickenside striæ in the silurian rocks, as they affect the joints as well as the beds, are due to the grinding together of the rocks during the carboniferous upheaval. The relative effects on the older rocks of these various "epoch" movements is an interesting problem difficult to work out, but of importance in dynamical geology. There is no doubt that the principal folding of the silurian is long prior to the carboniferous, and directly connected with the enormous sedimentation that preceded it. There have, however, been many revolutions of the earth's surface since silurian times, and I have shown that the effects of lateral pressure produced by change of temperature incessantly going on in the earth's crust is cumulative. Each rise of temperature, however small, when sufficient to move the rocks produces permanent upheaval.*

An attentive study of the form of the beds on the Great Orme's Head as viewed from a distance, discloses the fact that the curves are domical, and therefore have been produced by pressure acting centripetally. This form can be traced out in almost every flexed bed that I have studied. The domical form of many flexures has been frequently noticed by geologists that have worked in the field, but I am not aware of any who have held that the form is universal, or that synclinals are always basins in the true sense of the term.

The enormous amount of denudation that has taken place since the carboniferous upheaval is well shown in the comparatively small patches left of the limestone. On the North coast of Anglesey, carboniferous beds of limestone, sandstone, and shale, higher in the series, are to be seen. There is very little doubt but that the carboniferous limestone of the Eglwyseg rocks near Llangollen is part of a once continuous sheet which stretched from Anglesey through Denbighshire and Flintshire to Llanymynech. It is also extremely probable from the small

* Origin of Mountain Ranges.

and singular outlier near Corwen, which seems dropped down and preserved purposely to tell the tale that the limestone, at least, covered a large area of the mountainous district. In wandering about the mountains North, South, and West of Llangollen, nothing is more firmly impressed upon the mind than that the great wall of limestone rock which dominates the landscape is but the scarped edge of this thick carboniferous sheet worn back eastward from the mountainous district.

There are many other features in the neighbourhood that would well repay close study, and among them are the surface forms of the rocks, the glacial drift, and the post-glacial beds of the Conway. As I have already observed, the carboniferous beds are distinguished here by the long swelling curves they assume. In limestones the structural form is usually well brought out by its tendency to weather back in scarped faces along the edges of the beds. Between the carboniferous limestone and the glacial drift there are here no intervening formations. In the Vale of Clwyd, some ten miles to the eastward, the triassic sandstones occur; whether any representatives of this period ever existed in our immediate area, it would be difficult to say. The time which has elapsed since the carboniferous beds were upheaved is enormous, and the denudation that has taken place is equally great. It seems not unreasonable to conjecture that the triassic plain forming an extension of that of Cheshire, Lancashire, and the Vale of the Clwyd, stretched out in an unbroken line to the northwards on the site now occupied by the waters of the Irish Sea. There may even have been, as surmised by Prof. Judd, representatives of the lias and the chalk. When we come to consider the thousands of feet of rock which have been removed in tertiary times alone from some districts, there is nothing wild in these imaginings. Of time there has been plenty, but these are difficult questions for the future to work out, and, doubtless, the relations between sedimentation and mountain building, which I have, along with others, humbly attempted to investigate, will prove a key for unlocking many palæo-geographical riddles.

GLACIAL DRIFT.—Between Llandudno and the Little Orme the sea has eaten cliffs into the mantle of drift that covers the lower ground and partly creeps up the sides of the limestone headland. In 1884 I examined, and in 1885 described the drift between the Little Orme and Rhos Point, and from thence eastward to Colwyn Head.* Consequently, I was interested in seeing if the same arrangement of beds occurs on the West side of the Little Orme's Head. I find that although the beds are not so strongly differentiated that the nature of the drift is practically the same. Commencing in the ascending order, we have lying upon the foot of the limestone at the headland a greyish coloured clay, evidently largely made up of the destruction of the limestone beds, and containing many fragments of limestone. Traced along the shore or cliff westwards, it dips below the shore and reappears in several places through the gentle curves of its surface, until at last it appears to develop into a stiffer blue-grey till, more like that at Colwyn Bay. Upon the surface of this very clay and blue-grey till, reposes a boulder and shingle bed, cemented into a conglomerate by carbonate of lime, which also covers the stones as with a skin. It is as hard as, and indeed is, a natural concrete. One mass that had fallen on the shore from the cliffs was as large as a good sized room, and of that irregular picturesque form so sought after by rockery-builders. The stones imbedded are a blue stone, like Penmaenmawr felstone-porphyry, limestone, and some shales, all being either well rounded or sub-angular. The largest blocks are of limestone. The boulders and shingle in this bed are distinctly stratified into bands of gravel. Covering the whole of these beds is the well known brown boulder-clay, containing fewer stones and not so brown as that of Colwyn Bay. I had not much time for examination, and could find only a few striated stones, and these were in the blue till.

These drift deposits tell the old old story, subaerial waste, snow, and glaciers, and then progressive subsidence beneath

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The Drift Deposits of Colwyn Bay, Q.J.G.S., May, 1885, p.p. 102-7.

the waves. The boulder-bed is a shore deposit, the overlying brown boulder-clay being deposited in deeper water. I have shown that most of the sandy drift of Colwyn is derived from the triassic beds of the Vale of Clwyd. On the west side of the Little Orme the travel of material from this locality must have been considerably cut off by the headland, hence the difference in the character of the drift. I consider that all above the blue till belongs to the marine low-level boulder clay; underneath this the beds are of a character only found in the neighbourhood of mountains or high land, and which I have called Mountain and Hill Drift,* and this generalisation I have since found to hold for other localities, including the North-east of England.

POST-GLACIAL BEDS.—Between Llandudno Junction and Llanrwst the remains of a forest can be seen in the stools of trees, which project from the mossy lands resting upon the alluvium of the river. I am not aware of the depth of this alluvium, but having been the architect of the Llanrwst station some 25 years since, I well remember that the foundation of the goods shed was formed upon it, and as it was not considered very firm, special precautions were taken by spreading out buttresses underground to prevent subsidence at the angles of the building. The estuarine form of the Conway—the tide affecting the waters as far as Trefrew—shows that it is a subaerially formed valley which has subsided. The deposit between Rhos and the Little Orme points to the same fact. The low isthmus uniting the Great Orme with the main land upon which most of the town of Llandudno is built, is a marine or estuarine accumulation. I happened to see the trench which was cut for the main outlet sewer during the progress of the work. I cannot lay my hand upon the notes I made at the time, but I well remember that it was cut through a considerable depth of sand and gravels at the lower part. Since then it has hap-

* Drift Beds of the N.W. of England.—Q.J.G.S., May, 1883, p. 127.

pened that I have had to inspect a gas-holder tank supplying Llandudno, and I found that it was entirely excavated in grey estuarine clay, very like that associated with our peat and forest beds, but whether it is of the same age, or younger as I suspect, I had no means of proving.

The sketch I have had the pleasure to bring before you to-night is the merest outline, but it is sufficient, I hope, to show that subjects of intelligent interest can be found even in unsystematic rambles, if the eye and heart are kept open to nature's teachings.

MONTHLY NOTES.

"Nature" of June 16th contains an article by Sir William Dawson, President of the British Association, which should interest all geologists, inasmuch as in it are some details of a suggestion for the formation of an Imperial Geological Union. He shows that the British Empire possesses exceptional facilities for taking the lead of other nations in so far as geology and physical geography are concerned, and urges that a union of British and English-speaking geologists might lay a broad foundation of geological facts, classification, nomenclature and representation, which would ultimately be adopted by other countries, as far as local diversities and differences of language might permit.—A.N.T.

Not far from the already well known Cheddar caves, in Somersetshire, there was discovered on the 26th of May last, by Mr. R. Cox Gough and his son Arthur, an immense cavern in the limestone, near the Windcliff Rocks in the Cheddar Pass. This cavern, like those near it, will no doubt afford to geologists many interesting examples of water-action on limestone rocks.—A.N.T.

EXCHANGES RECEIVED.

Journal of the Liverpool Astronomical Society, parts 7 and 8 of vol. V.

FIELD MEETING.

On Saturday, June 18th, a Field Meeting was held at Leasowe, when the various deposits ranging from the recent blown sand through the Peat and Forest beds to the Boulder clay were studied, and the various problems relating to their age and origin were discussed. Mr. I. E. George and Mr. C. Potter rendered valuable assistance on the occasion.

ORDINARY MEETING,

Held at the Free Library, Monday, July 4th, 1887, Mr. A. Norman Tate, F.I.C., F.C.S., President, in the Chair.

MEMBER ELECTED.—Mr. J. Hornell.

EXHIBITS.—Indian Marble, by Mr. Westcott; and a small collection of Minerals sent from Queensland, by the Secretary.

A paper was read by Mr. C. E. Miles on "The Mersey Estuary."

FIELD MEETING.

On Tuesday, July 12th, a visit was paid to Mr. McFall's quarry, Bankfield Road, Green Lane, where interesting traces of glacial action were seen; on the east side of the quarry the upper stratum is seen to be greatly contorted; and on the north side the sandstones, which dip to the east, are bent back at their westerly outcrop as if caught by some body moving from the east and forced back upon themselves. Blocks of sandstone of a texture different to that of the quarry have been found with striated faces in the overlying soil, and others are found curiously flexured, bearing unmistakable marks of great pressure having been applied to them in an irregular manner, so that they are more compressed and bent in some places than in others.

Subsequently the company was conducted by Mr. W. S. Walker to a quarry near Club Moor, where a few contortions were seen, but the great feature of which was the broken character of the rock, the walls of the quarry being traversed by cracks in all directions.

"LIFE OF JAMES NASMYTH, ENGINEER."
Edited by SAMUEL SMILES.

It needs no apology for introducing to our readers an agreeable companion and an interesting narrative. A record of a long life of good-natured, well-directed energy, this autobiography appeals not only to artificers, as such, but also to that large miscellaneous class of workers who happen to have a scientific or artistic hobby. The name of Nasmyth will at least be familiar to those of our number who had the pleasure of inspecting some of his wonderful sketches of lunar volcanoes at Mr. Isaac Roberts's observatory last autumn. How his mechanical skill and powers of drawing came to be used for scientific purposes may be learned in the narrative; while we trust that the lesson drawn from the facts will be appreciated by those, if any, who fear that the absence of an academical training precludes them from doing any scientific work. To an engineer the solution of the mechanical problems which are so numerous in geology seems to offer little difficulty. Standing deep down in the Vesuvian crater, his attention divided between his sketch-book and the necessity of avoiding asphyxia, Nasmyth seems to have realised fully the power of igneous forces. Dealing with the sources of lava, he tells us that "there still remains an enormous mass of molten materials that has been shut up beneath the earth's crust since the surface of the globe assumed its present condition. The mineral matter that formed the globe had converged towards its centre of gravity, and the arrestment of the momentum of the coalescing particles resulted in intense heat. Hence the molten condition of the globe in its primitive state. The molten lava of volcanoes is the survival of that original cosmical heat." Some remarks on the origin of mountains may very appropriately be reproduced, now that the subject is receiving such attention at the hands of geologists. The illustrations are very happy, and their familiarity indicates the extent to which they have been utilised in recent text books. "Our mountain chains are, for the most part,

the result of a tangential action. In the case of the earth, the hard stratified crust had to adapt itself to the shrunken diameter of the once much hotter globe. This tangential action is illustrated in our own persons, when age causes the body to shrink in bulk, while the skin, which does not shrink to the same extent, has to accommodate itself to the shrunken interior, and so forms wrinkles—the wrinkles of age. This theory opens up a chapter in geology and physiology well worthy of consideration. It may alike be seen in the structure of the surface of the earth, in an old apple, and in an old hand." It is pleasant to follow the course of scientific thought in the middle of the century in the genial company of our author. Thus, at the British Association meeting at Edinburgh, in 1850, we listen to Hugh Miller, as he lectures on some scratched boulders which he tells us have been striated by ice action; and to Robert Chambers, when he demonstrates to us that the markings on the rocks of the Corstorphine hills have the same origin. For the rest we can cordially recommend the experiences of James Nasmyth, detailed in his book, as being those of "a guide, philosopher and friend."

I. E. George.

HINTS FOR A ONE DAY EXCURSION.

Assuming that five hours are allowed on shore, Llandudno offers all that can be desired for a geological outing. A very fine view of the Great Orme's Head is obtained from the deck of the steamer on nearing Llandudno, but the domical curves and general structure of the Head are best seen from the Conway Marsh. On reaching the end of the Pier, turn directly to the right and mount the Head, passing Mr. Kendrick's, "the Lapidary." There, it will be well to study the great sweeping curves of the strata, and the scarped face of the beds; on taking the next turn great quantities of red clay may be seen, forming an embankment against the sides of the cliff. This is not Boulder clay, but owes its origin to the decompo-

sition of the impure, argillaceous limestones. From this point the view is perhaps one of the finest a geological student can gaze upon. Below is the Conway Valley, with its glacial drifts; on the left Deganwy, with its two lumpy hills of Felspathic-trap, with contemporaneous Bala beds on their flanks; whilst one glorious range of mountain and valley stretches away as far as the eye can reach, which, from a denudation point of view, cannot be equalled in the country. On gaining the top of the Head, make directly for the copper mine, where, amongst the debris, very beautiful pseudomorphs of malachite and azurite, after pyrites, may be obtained, with many other copper, iron, and magnesian minerals. After doing the copper mine, take the path on the left, by the hedge-row, until the quarries are reached. Passing on the journey over the ordinary limestone, then the earthy amorphous limestone, when there will be found a bed of carboniferous shale; here a rich harvest of fossils will well repay the trouble of the journey. The shale holds the organic remains so loosely that they may be shaken out in handfuls.

Before leaving, notice that directly under the shale are the "Producta beds," a thick mass of limestone, made up entirely of the *Productus giganteus.*

P. H. Marrow.

EXCHANGES RECEIVED.

Transactions of the Mining Association and Institution of Cornwall, vol. I., part 3; Transactions of the Royal Geological Society of Cornwall, vol. II., part 1; Annual Report of Nottingham Naturalists' Society, 1886; Sixth Annual Report of California State Mining Bureau.

BANK HOLIDAY TRIP TO CASTLETON,

1st August, 1887.

Our trip to Castleton, talked of at intervals for years past, is now an accomplished fact, and there seems to be no reason to regret having spent a day in the Peak. Leaving Liverpool at an early hour by Matlock excursion, we were allowed by the Midland Railway Company to debark at Chapel-en-le-Frith, from which Castleton is distant 7 miles. The formations traversed were the millstone grit, Yoredale shales, and underlying carboniferous limestone. Taking car at Chapel-en-le-Frith, half-past eleven found us at Windy Knoll quarry, which we estimated to be about 1,200 feet above sea level. The road thither had for two or three miles passed along a slope of millstone grit, and it was interesting to note what a large number of *swallow-holes* existed in the limestone hard by, marking its junction with the overlying permeable strata. The summer being very dry, no streams were seen in these uplands, but it could readily be imagined that during a rainy season any water that ran down the grit slope of Rushup Edge would disappear into the fissured limestone. Our driver, Mr. Taylor of the Royal Oak, assured us that he had often emptied bags of chaff down the swallow-holes to learn afterwards of the reappearance of the material in the waters of the Peak Cavern at Castleton. At least one ebbing and flowing well seemed also to be a feature of the district.

The rocks at Windy Knoll quarry are famed for producing a very rare mineral, Elaterite, or elastic bitumen. This hydro-carbon at one time occupied a fissure in the limestone, but is now perched high up on the face of the crags. Its elevated position did not, however, prevent the securing of specimens. Some of our most respected members were soon aloft, and might have been seen clinging, like so many chamois, to the face of the rock, and admiring the rich brown colour of the viscid mineral, which seemed inclined to do anything but furnish portable specimens. Another hydro-carbon

seemed rather plentiful in the surrounding rocks, through which it was scattered in small patches. This mineral was jet-black, hard and brittle, not unlike coal in appearance, and, along with fluor-spar, filled most of the joints. One pocket of this dark substance measured about 18 inches across. With regard to the origin of the hydro-carbons, Dr. Ricketts, in drawing attention to the features of the deposits, suggested that their occurrence in the limestone was probably associated with the coal measures which once overlaid the carboniferous limestone and millstone grit of Derbyshire. Percolating waters working through the coal measures would be highly charged with carbon compounds, which, in their downward passage, would tend to fill up small hollows and fissures in the limestone. The same kind of thing had been noticed two years ago when the Association visited Shropshire. The stiper-stones quartzite at Pontesbury, close to a small coal-field, was seen to be plentifully sprinkled with bitumen, and the same is the case with the Cambrian conglomerate at Haughmond, situated on the northern margin of the same coal-field.

The descent from Windy Knoll to the Castleton road lay along the romantic gorge of the Winnatts, and great was the pleasure derived as we looked up at the huge buttresses of bleached limestone occupying the slopes 300 or 400 feet above our heads. At present without any stream, the gorge probably originated as a small water course, and has since been widened and deepened mainly by the solvent action of rain water. Two small gulleys which are now being excavated in the face of the steep slope intervening between Castleton and the Winnatts serve to show what the latter valley may have been like during a very early period of its history.

The Cave Dale basalt was thought by Dr. Ricketts to be intrusive, the evidence pointing in that direction. It made its appearance in two places, being surrounded by the limestone; whilst no signs of interstratification were seen, although at one point it developed a rude columnar structure vertically,

and could scarcely be said to have altered the limestone at its junction. A shelf of limestone forming a prominent feature on the higher slope of the dale, and immediately above the lava, was found to rest on a comparatively thick bed of volcanic ash, the rapid weathering of which caused the superior rock to be undermined.

In Castleton Churchyard was seen the grave of Elias Hall, the Father of Derbyshire Geology, who died, full of years, in 1853. The record on his tombstone is very gratifying reading to the geological student, and does honour to the friends who placed it there.

I. E. George.

Epitaph in Castleton Churchyard.—The following is the inscription referred to in above report.—D.C.—"In memory of Elias Hall, the Geologist, who died on the 30th day of December, 1853, aged 89 years. Born of parents in humble life, and having a large family to provide for, yet he devoted himself to the study of Geology for 70 years with powers of originality and industry rarely surpassed. To mark the last resting place of one who has worked so long and so hard for the public, a few of his friends and admirers living at a distance have placed this stone."

A Remarkable Valley.—By those who formed our party on Bank Holiday I believe that Cave Dale, in which the lava was examined, will be considered a remarkable valley, even for Derbyshire. One knows not whether most to wonder at the narrowness and comparative insignificance of the entrance, or at the great width and height of the dale, when once we have passed through its natural gateway. Like the gorge of the Winnatts, which lies about a mile further north, Cave Dale seems at one time to have been a channel for the drainage of the high limestone tract overlooking Castleton; but while the Winnatts maintains a good width at its lower end, the Cave Dale is almost closed up at its outlet. This would seem to imply that the quantity of water carried out of the valley along the surface must have been very insignificant during

the greater part of its history. That the rule by which valleys of erosion become gradually wider towards the lowlands does not apply to Cave Dale is evidently due to its having been fashioned out of a soluble rock, limestone, in which open joints and fissures are usually so abundant that the formation of a river on the surface is a matter of difficulty. At present the kind of denudation going on in the Dale is an almost imperceptible one. No river exists there to undermine the steep slopes, or excavate a deep channel in the rocky floor, and no waterfalls interfere with the stability of the cliffs. The work appears to be mainly done by rain water, charged with carbonic acid gas, trickling down the steep slopes and finding its way underground. Numerous immense joints are to be seen cutting right across the valley, and in many places these have been widened into small passages and caverns. A well developed system of joints will have a great influence on the recession of the cliffs. Where the joints are large and numerous, the surface exposed to the action of water will be greater than at a point where they are set further apart, and the limestone is more compact. In other words, the two slopes of the Dale may each be considered as escarpments, the faces of which are exposed continuously to atmospheric wear and tear, receding rapidly where circumstances are favourable, or forming bold projections where the rock is more obdurate.—I. E. G.

MONTHLY NOTES.

By the President.

The colour of the "Blue John" is destroyed by heating it in the flame of a Bunsen burner, the mineral becoming colourless. Experiments I have made indicate that this colouring matter is of organic origin.

The cave lately discovered at Cheddar by Mr. Cox-Gough has been visited by Professor Boyd Dawkins and several members of the Archæological Society. The Professor expresses pleasure in "having visited the caves and having

examined the valuable collection of fossil bones, illustrating the former condition of this country, and the human bones testifying to the ancient inhabitants of the stone age, and last, though not least, the singular place of refuge (with Roman pottery), which was inhabited some time in the fifth, sixth, or seventh centuries."

The Science and Art Department has granted permission to the Liverpool Science and Art Classes to hold field meetings for the study of Geology, such meetings to count towards payment on the results of the teaching. Teaching under such circumstances cannot fail to prove of the greatest advantage in supplementing the ordinary study in the class room.

A paper read before the National Academy of Sciences at Washington, by C. E. Dutton and Everett Hayden, published in "Nature" of July 21, 1887, gives valuable information respecting the Charleston earthquake, based upon information in possession of the United States Geological Survey. The same journal contains also a very interesting paper by Sir Wm. Dawson on "Fossil Wood from the Western Territory of Canada."

Fossil remains of an Arctic Flora have been discovered in Central Sweden, in the great stretch of land between Scania and Norrland.

A new gallery of the Natural History Museum, Cromwell Road, South Kensington, has lately been opened to the public, and contains the Historical and Type Collections in the Department of Geology and Palæontology under the care of Dr. Henry Woodward, F.R.S. The most ancient portion of this collection is the Sloan Collection, purchased for the nation in 1753. There is also the "Brander Collection," formed by Gustavus Brander in the early part of the last century, and also the collection of William Smith, alluded to in former "Notes." Besides these there is a collection known as "Sowerby's Mineral Conchology," begun by Mr. James Sowerby before 1812; the "Gilbertson Collection," purchased for the British Museum in 1841; and the "Searles Wood

Crag Collection," commenced in 1826, and presented to the British Museum in 1856, supplementary specimens having been presented by Mrs. Searles Wood in 1886. "The Eocene Molluscan Collection," formed by the late Mr. Frederick E. Edwards about 1835, and purchased in 1873, also finds a place in this gallery, as does the valuable collection of Brachiopoda, collected by Dr. Thomas Davidson between 1837 and 1886, and presented by him to the British Museum in 1886. Dr. Davidson devoted his entire life to the study and illustration of this one class of organisms. There is also a small series representing the "types," or "figured specimens" of Konig's Icones Fossilium Sectiles, prepared by Mr. Charles Konig, the first keeper of the Mineralogical and Geological Department after its separation from the general Natural History Collections in 1825.

L. Ricciardi has been investigating the gaseous emanations from craters and fumaroles, and in the case of the eruption of Etna in 1883, found that sulphurous anhydride was first evolved, and subsequently hydrogen chloride, which is contrary to the conclusions of Guy-Lussac, Bunsen, and others, who concluded that at the commencement of an eruption hydrogen chloride is evolved, succeeded directly by sulphurous anhydride and other compounds. Ricciardi considers that the hydrogen chloride probably arises from the decomposition of metallic chlorides, especially magnesium chloride, in the presence of steam at a high temperature. He shows that finely powdered granite and lava, mixed with pure sodium chloride, evolves hydrogen chloride, the quantity being increased by blowing in a current of steam. He suggests that the formation of sulphurous anhydride is in all probability due to the interaction of calcium and magnesium sulphates either singly or conjointly with the silica, whereby silicates are produced with separation of sulphuric oxide, which is decomposed into sulphurous oxide and oxygen. An artificial mixture of granite with magnesium or calcium sulphates evolved sulphurous anhydride.

S. Meunier has succeeded in the artificial production of rose spinel or balas ruby by heating together for five or six hours an intimate mixture of very finely powdered aluminium chloride and cryolite in a graphite crucible lined and filled up with a mixture of alumina and magnesia. A very small quantity of potassium dichromate is added when a rose coloured product is desired. The product is a greyish gangue, full of vesicles, which are lined with brilliant, rose-coloured crystals of balas ruby, identical with the natural crystals in form, colour, brilliancy, hardness, and optical properties. In referring to their experiments it is pointed out in the Journal of the Chemical Society of London that probably this is a further example of the mineralising action of fluorine shown by Fremy and Fremy and Verneuil, who have experimented with success on the artificial formation of rubies by heating together alumina and fluoride of barium or fluoride of calcium.

Artificial magnetite, closely resembling the natural mineral, has been produced by A. Gorgeu.

THE MERSEY ESTUARY.

By Charles E. Miles.

(Abstract of a Paper read at the July meeting of the Association.)

So striking are the results of the geological work effected by denudation that, appealing as they do so forcibly to our senses, we are apt to overlook the counter geological work of accumulation and the ultimate issues which it teaches. The two operations, though opposite, are equally important, but the results in the latter case are far less understood than those in the former.

Our member, Dr. C. Ricketts, F.G.S., is one of the few geologists who have directed attention to what a study of the work of geological accumulation naturally leads, and has stated his views in several papers, one on "Valleys, Deltas, Bays, and Estuaries," forming his presidential address to the Liverpool Geological Society for the session 1871-2.

The agents of accumulation may be divided into several classes, the work effected by each being distinctive in its character. Thus we have volcanoes and their deposits, mineral springs and their products, æolian accumulations, the reproductive effects of rivers in the deposition of sand and silt, and formation of deltas, lakes—as a rule their deposits have a distinct character. Tides and ocean currents have also their distinct work in accumulating deposits. The part played by ice is of the first importance, the clays produced by this agent being of a different class to those clays formed under other circumstances.

It will be seen that each class of agents of geological accumulation affords interesting subject matter for inquiry, the one, however, affecting us at present being the work of deposition accomplished by rivers and lakes. In connection with the subject we might take note of the effect of tidal and wave action in accumulating rocks. We have various examples on our own coasts, notably the Chesil Bank, on the Isle of Portland, a ridge of shingle about 17 miles long, which varies in height from 20 to 30 feet, and in one place to 40 feet above the ordinary high water mark. Nearer home, in Walney Island, off the town of Barrow, we have a capital example of this action, where for several miles on the west side the pebbles and boulders lie piled in terraces. These shingle deposits occur in very exposed situations, but in more sheltered spots the tides throw down sand, which after accumulating on the shore is often blown inland, forming our sand dunes. In this manner the sand brought down by rivers is in part returned by the sea and redistributed. In the same manner tidal action serves to redistribute sandbanks and redeposit sand in estuaries. Perhaps this action has not received that amount of attention which it deserves. In certain bays, especially those into which no rivers flow, this accumulating action of the tides is very noticeable, and it appears highly probable that the large deposits of sand now somewhat rapidly accumulating in the Mersey estuary are not

due so much to the action of the river and its tributaries as to tidal action. We have at Southport this tidal action now rapidly forming land to the west, and in fact the Lancashire coast, from Liverpool northward, is steadily advancing from this cause.

A great deal from time to time has been written about the Mersey estuary. Perhaps the most remarkable of these writings was a paper read by Mr. T. Mellard Reade, F.G.S., before the Liverpool Geological Society in 1873, called "The Buried Valley of the Mersey," in which he asserted, from ascertained geological data, that an older bed of the Mersey existed, much below the present one, as a rocky channel filled up with boulder clay, between Liverpool and Birkenhead. It is now a matter of history that since, in driving the Mersey Tunnel, those views proved to be most wonderfully correct. Thus it is shown beyond doubt that the present river and estuary flows mainly along the same channel through which it had flowed during pre-glacial times.

From the peculiar configuration of the banks of the estuary and the surrounding district the opinion, however, has obtained that the present estuary was formerly either marshy ground or it formed a lake. This idea is not much in favour, and has only been accepted by a few. It appears to have originated with Dr. Ormerod, in his "History of Cheshire," who considered that the upland waters of the Mersey formerly took a direction across the Hundred of Wirral, and found an outlet in the waters of the Dee. It has been attempted to be shown by others that while the estuary formerly existed as a lake the waters found an outlet to the sea through Wallasey Pool. Sir James Picton has advocated the lake idea, and Mr. Joseph Boult, before the Literary and Philosophical Society, Liverpool, in 1873, in a paper entitled "The Mersey as known to the Romans," gave strong presumptive evidence in favour of this point. Although differences exist amongst writers as to the exact manner in which the waters flowed from the lake to the sea, and also whether the lake covered the whole or

part of the ground now forming the estuary, topographical evidence appears chiefly to be the foundation upon which the theory has stood, the geological evidences not being so well advanced as they deserve to be.

I consider that the best evidences of what the Mersey estuary was in former times may be gathered from a close observation of those deposits which were at one time formed by the Mersey or its contiguous waters. On examining the ordnance maps the appearance of the banks outside the Mersey suggest the idea very strongly that at one time they were continuous, stretching as they do from Hoyle Bank to the Formby shore, with channels cut through. This in itself is no evidence, but taken in conjunction with the fact that on the shore at each side exist thick beds of peat, resting on some four or five feet in thickness of blue clay, now rapidly eroded by the tides, there appears no reasonable ground for objection to the idea that within comparatively recent times the peat and clay stretched across and covered the banks where the tide now flows.

The question at issue is whether the blue clay is the relic of some former subsidence of the land and subsequent upheaval, or is it some deposit formed in a lake or river channel without disturbance. The character of the deposit shows that it was thrown down in comparatively still waters. If we look at the subject in the light shown by the work done by geological accumulations, we may arrive at conclusions which will perhaps better account for the facts. From the evidences in the deposits I take it that at the close of the glacial period, when the river would be much shallower and extending further out to sea, it is most probable that owing to tidal or other action the mouth became almost totally barred by deposits of sand and clay. This gave rise to a lake now occupied by the estuary, which, slowly filling up by deposits of blue clay arising from washed boulder clay brought down by the river and its tributaries, gave rise eventually to marshy ground and subsequent peat. This condition lasted for some

considerable time, as evidenced by the thickness of the peat deposits, which in some places average 5 feet in depth. On several parts of the surface of the peat at Leasowe can be noticed beds of black soil containing fresh water shells, pointed out to me by Dr. C. Ricketts, showing the remains of old pools of fresh water where the tide now flows at high water. In the course of time and change of tidal currents the openings through which the river flowed to the sea from the lake became widened from erosion of the sea, and the estuary ultimately formed.

NOTES.

Mr. W. M. Hutchings, of Chester, asks, in "Nature" of September 15th, whether the occurrence of crystallised *apatite* has been noticed in a metallurgical slag or other artificially formed silicate. He states that he has observed its formation in a slag produced during the smelting of lead ores in a blast-furnace. In the reduction of the ore the principal "flux" used is "tap-cinder" from puddling furnaces, and it is mainly from this source that phosphoric acid is introduced into the slag.—A.N.T.

The International Geological Congress will meet next year in London, and it is certain that a large number of Continental and American Geologists will then visit this country. The Committee of the Congress met in Manchester at the same time as the British Association. One object of this Congress is to discover the nomenclature and classification adopted by different authorities and in different countries, with the view of bringing their views into harmony, and also to lay down rules for the guidance of geological workers in the future.—A.N.T.

ORDINARY MEETING,

Held at the Free Library, Monday, September 5, 1887, Mr. H. T. Mannington, Vice-President, in the Chair.

Nominations.—Mr. Robt. Jackson, 6, Hesketh Street; Mr. J. Butler Davies, 71, Boswell Street; Mr. Frank O. Cresswell, 22, Kings Road, Bootle; and Mr. W. D. H. Deane, M.A., 2, Arundel Avenue.

Exhibits.—Mr. G. Watson Gray, A.I.C., exhibited some specimens of Natural Alum found recently at Gilsland on an exposed face of lower carboniferous shale; being a soluble mineral, its being found in such a position is an indication of the extreme dryness of the past season.

Papers were read on the following subjects:—"Use and Abuse of Stone in Building," by Jas. Wilding; "Notes on some Weathered Rocks at Hilbre," by I. E. George; "Fossil Teeth," by Cecil F. Webb.

THE USE AND ABUSE OF STONE IN BUILDING.

By James Wilding. (Abstract.)

From almost the earliest times man has employed stone for building purposes. He would have no difficulty in using the softer sandstones, but we find that the early Egyptians also used the harder stone, such as granite, in the erection of their Pyramids. That the early builders exercised great care in the selection of their material is evidenced by the time they have lasted, most of those in which granite is used being still in a good state of preservation. If such care had been exercised by our mediæval architects we should have many fine specimens of their skill extant now. We have in the neighbourhood of Liverpool good building rocks. The Triassic

sandstones of Runcorn, Woolton, Everton, and Storeton are very good for building purposes. In the course of business it has fallen to my lot to select blocks from the various local quarries, and I usually found the good stone at the depth of about 30 feet below the surface. The upper beds are generally shaley and unfit for building purposes. Storeton stone, from Storeton Hill, Cheshire, is a difficult stone to deal with, owing to the number of minor faults existing in it. The abuses of sandstone may be summarised as follows:—The placing it on its "teeth," or off its natural bed; its usage in damp situations, such as cellars, without proper precautions against the wet.

The first may be avoided by the builder having a thorough knowledge of the bedding of the stone he uses. To distinguish this is easy to a practised eye—to an unpractised it is not so easy. The second may be overcome by using a substitute for stone in very wet places which will be impervious to moisture; the "backing up" of the stones used with bricks and cement, and the use of sheet lead for the beds of coping and such like stones; careful supervision during quarrying in order to prevent inferior stone leaving the quarries.

The building uses of stone are many. It is specially useful to the builder from the ease with which it lends itself to architectural requirements such as ornamentation. Briefly, I may enumerate a few stones used in our town. The Yorkshire sandstones, which are varied in colour and hardness, but are all excellent building stones—these can be used anywhere. Bath stone is better used in the interior; and Granite, which is excellent for basements, when chosen carefully, and those with an excessive amount of felspar rejected. Many others might be mentioned which are well adapted for special work, but in all cases we learn from the foregoing remarks that care in selecting and using stone in buildings is of primary importance, and also that a knowledge of its geological structure, together with a practical acquaintance with the quarries from which it is taken, would be and is extremely beneficial.

NOTES ON SOME WEATHERED ROCKS AT HILBRE.

By I. E. George.

To those who know it well, the little group of islets at the mouth of the Dee estuary will always be regarded as forming excellent ground for the study of dynamical geology. At each visit something new may be learnt, and there would seem to be no end to the problems connected with its structure. Regarding the appearance of the group as a whole, there is no doubt that it is the sea which has been mainly instrumental in giving to the rock-masses their outlines. At the present time the waves appear to be very potent agents of denudation on the western coast line, whilst a study of the eastern shore seems to show that marine action in that quarter is not so violent now as it was at some past period, when the land stood at a relatively lower level. The linear arrangement of the three islets from north to south is not quite coincident with the direction of strike of the rocks composing them, but more exactly follows the direction of an important series of joints, whilst their separation from one another has been influenced by the occurrence of easily weathered clay seams, through which the waves have made a breach.

The broad results of denudation, then, are tolerably evident to any inquirer who visits Hilbre, but the various stages of the process by which these results have been arrived at have not received the attention they deserve. This is specially the case with structures that, placed beyond reach of the waves and the scouring action of the sand and gravel which they drive along, are still low enough to be very frequently washed with spray, and it is to these that I wish briefly to draw attention. They appear as serrated outlines on the eastern faces of the cliffs bounding Hilbre and Middle Eye, as fine pittings in the western face of the Hilbre cliff, and as small rock-basins on the highest points of the reefs surrounding and connecting the three islets. For simplicity in dealing with them, I would divide these structures into three groups according to origin :—(*a*) Serrated outlines

developed in connection with stratification planes and small joints; (*b*) Pittings showing former presence of clay nodules or soft pebbles in the sandstone; and (*c*) Pittings and rock-basins showing general action of dissolving waters on rocks of tolerably uniform texture. The first group is very finely developed on the eastern shores of Hilbre and Middle Eye, where a thinly bedded yellow sandstone is weathered along the bedding planes. The seams are only an inch or two in thickness as a rule, and the exposed side of each has been bevelled off to a sharp edge both from above and from below. No doubt the resulting horizontal grooves between the seams must be continually deepened and have their outlines influenced by the play of spray upon them, and from the fact that moisture lodged in the grooves would be well preserved from evaporation, it would follow that chemical action resulting in the disintegration of the rock would go on at a more rapid rate there than on the prominent edges of the seams, where moisture would vanish more quickly. Very small joints, when closely packed together, have sometimes given rise to the same kind of structure as the foregoing, excepting that the resulting grooves are vertical.

The group *b*, to which I have referred, occurs on a sandstone platform scoured by the waves on the eastern side of Middle Eye. Pebbles of a softer sandstone occur in the rock at this point, and the origin of numerous little vertical pits, usually full of water, may with probability be referred in this instance to the more rapid disintegration of the included fragments.

The small horizontal rock-basins of group *c* are just within reach of the waves at high tide. They seem to owe their origin to the chemical disintegration of the felspar and ferruginous cement of the sandstone by the sea-water which rests in the hollows of the rock. Waves finding their way into these basins would acquire a rotary motion, and by their scouring would materially assist the chemical action. But they would also clear away the loosened material from the

rock-surface, thus allowing the development of rock-basins to go on uninterruptedly. Here we have the lighter sea-waves accomplishing a purpose which on exposed moorlands is done by the wind. It is evident that if the rocky hollows be not cleaned out periodically they will soon be choked up, and the subsequent stages of denudation will not be marked by the occurrence of any regular outlines. In the case of granite, rock-basins of a similar form are developed by the solvent action of rain-water on the surfaces of large masses resting in exposed situations, where the wind has sufficient power to remove the loosened particles of insoluble matter out of the way.

A singular development of the group of pittings now under consideration is seen on the south-west face of the Hilbre cliff. These differ, however, from the rock-basins in being developed on a vertical face of rock, though their origin appears to be likewise due to chemical disintegration. Placed close together in large numbers, and striking horizontally into the sandstone for a couple of inches or more, they seem to the beholder as if giant finger-tips had been pushed into some plastic material. The rock in which they appear being homogeneous, and showing no trace of enclosed fragments of a softer material (the rapid weathering of which might produce hollows), I am inclined to regard the pittings as being due mainly to chemical solution of some of the constituents of the sandstone. Water occupying the hollows is certainly protected from evaporation for long periods, and, being placed on a part of the coast much exposed to the wash of spray, the pits will very rarely be entirely free from moisture. This fact will probably account for their wonderful regularity and depth at Hilbre. Finally, it may be remarked that other localities in our neighbourhood furnish somewhat similar evidences of the very gradual crumbling away of rocks exposed to the weather, but none, I think, more strikingly than the little outlying patches of Triassic Sandstone at the mouth of the Dee estuary.

FOSSIL TEETH.

BY CECIL F. WEBB.

The development of the teeth is one of the most curious and interesting processes of growth in the body, and the structure of a human tooth will supply us with a clue by which we may understand the formation of similar organs in the vertebrates generally; it is composed of four distinct structures:—

1st—The *dentine*; this forms the great mass or mould of the tooth. 2nd—The *enamel*; constituting the exterior coat of the crown. 3rd—The *cementum*; this forms a thin layer around the root, not including the foramen where vessels and nerves enter, and is traced over the enamel. 4th—The *pulp*; which is found in the central cavity of the dentine. Two sets of teeth are developed in the human jaws—the first called the deciduous or milk teeth, which supply the wants of childhood; the second the permanent, which are supposed to continue through life. The temporary set are twenty in number, and consist of two central and two lateral incisors, two canines, and four molars or double teeth in each jaw. The permanent teeth are thirty-two in number, sixteen in each jaw, and are in pairs, eight on each side. This includes twelve teeth not found in the temporary set, viz., eight bicuspids and four wisdom teeth. Each permanent tooth is formed in a little sac, which at first is but a prolongation of the sac of that milk tooth which it is destined to succeed. The fangs or roots of all teeth are firmly fitted into corresponding shaped cavities in the bone of the jaw, which cavities are termed *alveoli*; and this mode of union of parts (like a nail driven into any substance) is termed *gomphosis*.

The distinctive conformations exhibited amongst the teeth of different species of the animal kingdom have rendered them the safest guide to determine the several species and varieties of extinct animals. The character of a bone or bones of a limb, or a tooth, or even a portion of them,

determine the whole formation of the animal. They also constitute an index of the habits, mode of existence, character of food, haunts, size, and every other distinction peculiar to those animals which lived upon the earth before the creation of man.

On examining the jaws of carnivorous animals, we find a set of cutting teeth called incisors in front, canine teeth on the sides, and the molar or crushing teeth further behind. These last rise into sharp cutting points, and in the upper and lower jaw overlap each other like the edges of a pair of shears. The jaws open and shut like a hinge, and thus admit of no grinding motion.

The herbivorous animals, or those which live on vegetables, have no sharp canine teeth; and the enamel instead of being laid on the top of the teeth is laid in deep vertical layers, alternating with bony matter, so as to form a grinding surface. The flat molar teeth are used to masticate or grind, to reduce into pulp the soft vegetable substance. The jaws, too, are loosely articulated, so as to allow a sort of rotary or lateral movement; and the muscles correspond in position and power with the design in view.

Another class of animals called *rodentia,* or gnawers, of which the beaver, squirrel, rabbit, &c., are examples, have long cutting teeth like nippers; the front teeth are large compared with the molar teeth, and are so interlocked as to allow no grinding motion; and the lower jaw is so constructed, that, instead of working in the skull transversely or laterally, it works lengthwise, the teeth moving backwards and forwards like a carpenter using his plane. The cutting teeth are also liable to be worn away by constant use, and therefore are renewed by continual growth, and there is a special provision for their support in a bent socket. The enamel is very thin behind and thick in front of the tooth, so that the cutting edges are kept sharp, as by the act of gnawing the hinder part wears away sooner than the fore part, and thus an inclined edge like that of a chisel is continued. The enamel of

the molar teeth, also, is placed vertically and transversely, so as to form an admirable grinding surface.

From these examples it is evident that the practised comparative anatomist can easily discover by a tooth the class of animals to which it belonged, and, consequently, the kind of vertebræ and other bones which the creature must have had. The animal by this means may be restored, and a drawing made of it such as it probably was when living, and its habits and economy described. The nature of the country which it must have inhabited, its climate, productions, &c., may likewise be deduced from these prior conclusions. Thus Cuvier, Blumenbach, Owen, and others have been enabled to form numerous types of species, and to describe various peculiarities they possessed, which would otherwise have remained unknown. Thus, Prof. Owen discovered the gigantic fossil Megatherium of South America, from the evidence afforded him in examining the formation of a fragment of a tooth. This difference in the structure of teeth affords the naturalist the means of discovering to which group or species of animals any particular formation of tooth may belong; the formative arrangement being invariable and constant for each individual group. The portion of the fossil tooth referred to, which guided Prof. Owen in his palæontological investigations, belonged to the family Edentatæ. Upon minute examination of the structure of this fragment, he found an exact analogy existing between it and the sloth species, living at the present time.

The system of the teeth of the common sloth of our time is very simple. It has very small canines and no incisors; the arrangement consists of eight molars in the upper, and six in the lower jaw; they are without roots, and of simple cylindrical form and structure. These teeth are not at all fitted for grinding. The sacculated formation of the sloth's stomach is adapted only to receive masticated pappous shoots and leaves, and makes provision for this apparent deficiency by compensating for want of hardness and strength of the teeth; we accordingly

find the teeth of the sloth not at all adapted for grinding, but merely to break down the tender downy structure of shoots and leaves. Prof. Owen, perceiving the immense size of the tooth under his examination possessing attributes for tender food only, argued, notwithstanding this apparent delicacy of structure and feeble organization of the tooth, monstrosity in the animal owning it. This presented a difficulty. How could such an unwieldy monster, as this animal must have been, climb trees to feed and obtain subsistance, as do the sloths of our time? and again, what tree could bear such prodigious weight? These questions had to be answered.

Prof. Owen, contemplating the whole shape and make of the Megatherium under investigation, came to the conclusion that its enormous fore feet were formed to burrow down, so as to undermine trees. The animal then rearing on his hind legs and tail, which last was of enormous dimensions, by its weight pushed against the trees, and felled them to the ground; the meal now lying at its feet, he browsed of its dainties at his leisure. The mouth of the Megatherium contained five teeth on each side of the upper and four in the lower jaw, being without incisors or canines, and they were also remarkable for the thick coat of *cementum* investing them. The teeth had no roots.

The most important of all the animals yet discovered in the ancient world is the Mammoth. Its teeth, like those of the Indian elephant, have a broad united surface, with regular furrowed lines of large curvature. They are four in number, like those of the elephants, two in each jaw. Another very interesting animal is the Mastodon. It derives its name from two Greek words signifying mammillary teeth, because the thick enamel which is spread over the crown of the tooth when unworn is divided into several transverse processes, each of which is also sub-divided in obtuse points. These teeth, unlike those of carnivorous animals, have no longitudinal and saw-like cutting edge. They resemble rather those of the hippopotamus, and seem designed for bruising and masticating raw vegetables, roots, &c. The animal was somewhat like the

elephant, but had a longer and thicker body. It had a trunk, tusks, and four molar teeth in each jaw, but no incisors or cutting teeth.

In the Pachydermata the teeth consist of two sets, and succeed each other in the usual manner. The grinding teeth, however, of these animals may be distinguished in different genera and families by the folds or pattens of enamel which mark the worn surface of their crowns. In the horse the incisor teeth possess the great peculiarity of a fold of enamel in their centres, as well as on the exterior surface of the crown. A great variety of these mammals were discovered in the gypsum quarries of Montmatre, and passed comparatively unnoticed by the naturalists of Paris, until Cuvier perceived that a new world was open to his researches, and he soon obtained an extensive collection. "I cannot," remarked this illustrious philosopher, "express my delight on finding how the application of one principle was instantly followed by the most triumphant results. The essential character of a tooth, and its relation to the skull, being determined, immediately all the other elements of the fabric fell into their places, and the vertebræ, ribs, bones of the legs, thighs, and feet, seemed to arrange themselves even without my bidding, precisely in the manner I had predicted." A few of the fossils were remains of the Palæotherium, Anoplotherium, and Xiphodon. The teeth on being examined exhibited such form of structure that at once showed that the animals must have belonged to the herbivorous tribe. The Palæotherium magnum was about the size of a horse, but thicker and more clumsy; its head was massive, and its legs and tail were short. The generic characters of the beast give them forty-four teeth, namely, twelve molars, two canines, and twenty-eight others. The molar teeth bear considerable resemblance to those of the Rhinoceros. The Anoplotherium commune was of the height of the wild boar, but its form was more elongated; it had a long thick tail, like that of the Kangaroo, and the feet had a divided hoof, or two large toes, like those of ruminating animals. It had posterior

molar teeth, analogous to those of the Rhinoceros, but no canine teeth, hence its name, which signifies "unarmed wild beast." The Xiphodon gracile was of elegant proportions, resembling in size and form the Gazelle, and must have lived after the manner of the deer and antelope.

Passing from the Mammalia to the cold blooded vertebrates, who make their first appearance in the Carboniferous period, but obtain their maximum development in the Mesozoic epoch, which is sometimes called the "Age of Reptiles." The teeth have but one fang, and are not generally sunk in separate sockets or alveoli. A well-known reptile is the Megalosaurus; the structure and arrangement of the teeth prove that it was carnivorous. It fed on other reptiles of moderate size, such as Crocodiles and Turtles, which are found in the same beds (Lower Cretaceous Period). The jaw is the most important fragment of the animal we possess, and shows that the head terminated in a straight muzzle, thin and flat on the sides, like that of the Gavial. The teeth of the Megalasaurus were in perfect accord with the destructive functions with which this creature was endowed. Dr. Buckland says:—"The teeth were constructed so as to cut with the whole of their concave edge; each movement of the jaws produced the combined effect of a knife and a saw, at the same time that the point made an incision like that made by the point of a double-cutting sword. The backward curvature taken by the teeth at their full growth renders the escape of the prey, when seized, impossible."

Another very interesting Dinosaur is the Iguanodon. The teeth, which are the most important and characteristic organs of the whole animal, are not fixed in distinct sockets, but are fixed on the internal face of a dental bone, that is to say, in the interior of the palate, as in Lizards. The place thus occupied by the edges of the teeth, their trenchant and saw-like form, their mode of curvature, the points where they become broader or narrower which turn them into a species of nippers or scissors, are all suitable for cutting and tearing the

coriaceous resisting plants of the Cretaceous Period. A most singular group of Pterosauræ, which inhabited the Mesozoic period, were the Pterodactyli. Cuvier proved from their organisation that the animals were Saurians. They had the form of a bird in their heads, of a bat in structure and proportion of their wings, of reptile in size of head and beak, and were armed with about sixty pointed teeth. The Plesiosaurus was a marine carnivorous reptile, with the head of a Lizard and teeth of a Crocodile. The extraordinary creature which bears the name of Ichthyosaurus was an exclusively marine animal. The teeth resemble those of the Crocodile ; these are conical, and are arranged in a long and continuous trench hollowed in the bones of the jaw, and any lost tooth could be renewed many times, for above every tooth there was the substance for a new one. The animals have been found armed with a hundred and sixty teeth.

Tne Labyrinthodon was a gigantic air breathing reptile connected with the Batrachian order. Its jaws were armed with conical teeth, implanted in distinct sockets. They consisted of a close set series of subequal teeth. placed along the margins of the upper and lower jaws; two or three canine shaped teeth, three times the size of the others, were placed between the inner and outer rows of the smaller rows in the upper jaw, and the same in the lower. Specimens of this creature's foot-prints have been seen in the triassic rocks at Storeton Quarry in Cheshire.

In the Sharks the triangular teeth are placed in successive rows, either one behind the other or arranged alternately; all these teeth, however, are not equally developed; as they proceed from without inwards, they become more and more imperfect, the innermost rows being mere rudiments of teeth. They are covered with hard enamel, which has favoured their preservation. They are very common in the Tertiary Period.

Thus, we see the form and structure of teeth have assisted to determine the genera and species, not only of existing animals, but those which have existed in the world before the

creation of man. The harmonies thus observed between extinct and living animals in their osteological structure and arrangement, form a basis upon which to unravel many interesting mysteries in nature.

FIELD MEETING.

On Saturday, September 10, a field meeting was held at Thatto Heath, conducted by Mr. D. Clague. A clay pit in the coal measure was first visited; many fossils were obtained. Some interesting examples of cone in cone structure in the shale were studied, and some traces observed of the breaking up of coal seams, the coal dust being distributed through the boulder clay.

A second section was visited, in which a coal seam dipping to the south-east at an angle of 20 degrees had been caught at the outcrop and bent back upon itself; the same features were observed in the accompanying clays.

Next several outcrops of coal were observed, and traced across the common toward a clay pit near St. Helens, where the coal seams were seen in section, and other features of a most interesting character were studied.

Glacial Contortions.—There can be little doubt that the flexure of the coal seam referred to above is an evidence of glacial action. The Green Lane section, described on p. 75, and the Moorhey cutting which we examined in the company of Mr. Mellard Reade in June, 1885 (Transactions, Vol. V., p. 57), both indicate the same points as the Thatto Heath cutting, namely, the movement of powerful sheets of land-ice, with their accompanying boulders, from north to south. Under the circumstances, then, it would not be too much to say that a careful look-out should be kept for similar features wherever shales, soft sandstones, or coal seams, having a southerly dip, are exposed in section near the surface. We feel sure that such instances must be pretty common over the low ground of S.W. Lancashire.